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by

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ABSTRACT

Two studies were conducted during fall and early winter at Swift Current to evaluate the performance of beef cattle grazing stockpiled forage. Study 1 determined the performance of weaned calves (WEAN) and cow/calf pairs (PAIR) grazing Russian wild ryegrass (RWR) in comparison to calf performance in the drylot on grain and hay (DRYLOT). Data were collected for calf average daily gain (ADG) and ultrasound backfat (BF) for both years of the study. Calf forage intake data and cow ADG and BF data were collected in year two. In 1997, calf ADG (0.36, 0.32 and 0.21 kg d^{-1}) was significantly greater ($p<0.05$) for DRYLOT and PAIR compared to WEAN. Calf final BF was significantly greater ($p<0.05$) for DRYLOT and PAIR (3.5 and 3.2 mm) compared to WEAN (2.1 mm). In 1998, calf ADG (1.0, 0.85 and 0.55 kg d^{-1}) was significantly different ($p<0.05$) between DRYLOT, PAIR and WEAN, respectively. Calf BF data indicated no significant difference ($p>0.05$) in 1998. Data for the cows in 1998 indicated no significant differences between the lactating and dry animals for ADG or BF. Extension of the grazing season with RWR may allow delayed weaning of calves without being detrimental to cow body condition.

Study 2 contained two trials to evaluate the performance of beef steers grazing western wheatgrass (WWG), native mixed grass (NMG) pastures or swath grazing barley (SGB). The second trial was a modification of trial 1 to include an evaluation of the effect of energy and protein supplementation (+S) provided by pelleted barley and canola meal fed at a rate of 1kg hd^{-1} day^{-1}. Trial 1, 1997, compared WWG, SGB, feedlot forage fed (FFF), and feedlot forage with supplemental grain (FFG). Trial 2, 1998, compared native mixed grass (NMG), NMG+S, WWG, WWG + S, SGB, SGB+S, FFF, and FFG. Data were collected on ultrasound BF depth

and ADG. In trial 1, backfat change (1.5, 0.9, -0.1, and –0.2 mm) differed between treatments (FFG, FFF> SGB, WWG; $p<0.01$). Average daily gain (0.9, 0.7, 0.1, and 0.1 kg day^{-1}) differed between treatments (FFG> FFF> SGB, WWG; $p<0.01$). Trial 2 backfat changes (–0.2, –0.2, -0.4, -0.6, -0.6, -0.7, -0.8 and -1.0 mm) were not significantly different between treatments ($P>0.05$). Average daily gain of grazing steers was increased by supplementation (0.2, 0.5 kg day^{-1}; no S vs. +S; $p<0.01$) and differed ($p<0.01$) between treatments (1.0, 0.8, 0.6, 0.5, 0.4, 0.2, 0.2, and 0.2 kg day^{-1}), for FFG, SGB+S, FFF, NMG+S, SGB, WWG+S, NMG and WWG respectively. Swath grazing barley or native grass mixtures with an appropriate supplement may be a suitable alternative to feedlot backgrounding of calves during fall and early winter.

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LIST OF ABBREVIATIONS

AAFC	Agriculture and Agri-Food Canada
ADF	Acid Detergent Fibre
ADG	Average Daily Gain
BCS	Body Condition Score
CP	Crude Protein
DOMI	Digestible Organic Matter Intake
FOM	estimated Fecal Organic Matter output
GNG	Green Needle Grass
IVOMD	*in vitro* Organic Matter Digestibility
MP	Metabolizable Protein
NDF	Neutral Detergent Fibre
NE_g	Net Energy for Gain
NE_m	Net Energy for Maintenance
NPN	Non Protein Nitrogen
NWG	Northern Wheatgrass
OMI	Organic Matter Intake
RDP	Rumen Degradable Protein
RTUS	Real Time Ultra Sound
RUDP	Rumen Undegradable Protein
RWR	Russian wild ryegrass
SPARC	Semi-Arid Prairie Agriculture Research Centre
WWG	Western Wheatgrass

Chapter 1

Introduction to Stockpiled grazing

Saskatchewan beef cattle production is focused on the cow/calf enterprise (Saskatchewan Agriculture and Food, 1996). The majority of calves produced are sold in the fall, shortly after weaning. A smaller proportion of the calves are backgrounded in Saskatchewan and an even smaller segment of the calves undertake finishing activity within the province.

Backgrounding is the process by which a calf's growth rate is controlled below the maximum genetic potential, in order to obtain frame growth prior to finishing activity for improved economic returns (Marsh and Greer, 1994; Vaage et al., 1998). The resulting product is a larger carcass at the same fattening endpoint than if the animal had undertaken finishing activity following weaning. In order for backgrounding to be effective, inexpensive forms of feed must be utilized. The least expensive feed source is one which the animal harvests itself and cost effectively handles manure (Adams et al., 1994; Klein, 1996). Interest in finding ways to background calves on pasture following weaning has been increasing.

In order for the backgrounding phase to be successful, the forage needs to be of adequate quality and quantity to satisfy the animal's requirements for the desired growth rate. During late fall and early winter, forage quality is nearing its lowest point. Mature plant stems tend to be high in fiber while the level of crude protein has declined. Selection of an appropriate forage species is therefore important to the success of stockpiled grazing for backgrounding. Shortfalls in forage quality may be overcome through the use of appropriate supplements if it is economically feasible to do so.

The studies contained within the pages of this manuscript provide information about forage quality and quantity and the resulting animal performance derived from various forages. Animals either grazed Russian wild ryegrass (*Psathyrostachys junceus* (Fisch.) Nevski, formerly *Elymus junceus* Fisch.), western wheatgrass (*Pascopyrum smithi* (Rydb.) A. Löve, formerly *Agropyron smithi* Rydb.) , native mixed grass, or swath grazed barley (*Hordeum vulgare.* cv. Bonanza). Control treatments were established in a drylot setting where the animals received rations based on free choice hay, with or without supplemental barley grain. The studies were conducted at the Semi-arid Prairie Agricultural Research Center (SPARC), Agriculture and Agri-Food Canada, Swift Current, Saskatchewan during the fall and winter of 1997 and 1998.

Chapter 2

Literature Review

The following chapter contains a review of the literature for topics relevant to the studies conducted. Various topics, such as, management practices, extension of the fall grazing season, supplementation efforts, and forage yield estimates are drawn from a wide body of scientific literature. Literature dealing with quality characteristics and yield parameters for the majority of the grasses under study, was available from work performed previously at the Semi-arid Prairie Agricultural Research Center (SPARC).

2.1 Backgrounding

2.1.1 Backgrounding Defined

Backgrounding is defined as a period of controlled growth to maximize protein deposition and bone development while minimizing fat deposition, for a net economic benefit (Marsh and Greer, 1994; Owens, 1995). A review by Owens et al. (1995) provides much insight into backgrounding in both the historical and current interpretations of the term. The historical definition of backgrounding is the controlled rate of growth to increase frame size prior to deposition of fat to create a larger carcass at slaughter. The current interpretation of backgrounding, pays attention to backfat endpoints, hormonal status, days of age, as well as frame size. Coleman et al. (1993) indicate that for early maturing beef breeds, a moderate growth rate to 75 % of slaughter weight is desirable to provide a more acceptable carcass.

2.1.2 Compensatory Growth

Fundamental to the process of backgrounding is the concept of compensatory growth (Coleman and Evans, 1986). Following a period of restricted growth, animals may exhibit accelerated growth in comparison to similar animals which had not been subjected to growth restrictions. The accelerated growth is known as compensatory growth. According to Wright and Russel (1991) compensatory growth is the result of an increase in the rate of protein deposition as evidenced by the carcass compositions in their study. The carcass composition of animals fed a restricted diet up to 350 kg, contained a significantly higher proportion of protein and water and less fat at 400 kg than carcasses of animals which were provided a higher level of intake from the beginning of the study. As the animals grew from 400 kg to 450 kg, carcass composition of the restricted animals more closely resembled those of the animals with a higher level of intake. However, the backgrounded animals still trended towards significantly greater bone mass, and less subcutaneous fat.

2.2 Animal Growth and Development

Weaning of calves is a critical event. Accumulation of muscle mass along with bone growth and development are highly active at this time in the sigmoidal growth curve. In order to insure correct development, certain elements of the diet must meet minimum criteria. Specific concern should be placed on the crude protein content, and on the mineral elements, calcium and phosphorus.

2.2.1 Nutrient Requirements

2.2.1.1 Protein Requirements

Crude protein requirements for various classes of animals may be calculated from the equations derived and provided by the NRC (1996) Beef Cattle Requirements. The requirements for medium framed calves weighing 220 kg to 290 kg, are in the range of 200 to 570 g Metabolizable Protein (MP) day^{-1}, corresponding to maintenance through weight gains of 1.0 kg/d. Metabolizable Protein refers to the protein available for absorption in the small intestine from microbial protein synthesized from rumen degradable protein (RDP) and non protein nitrogen (NPN), and from rumen undegradable protein (RUDP).

2.2.1.2 Response to Supplemental Crude Protein

In instances where crude protein levels are significantly reduced in comparison to the energy intake of the diet, response to protein supplementation, should be indicated by increased weight gain. Investigations of animal response to supplemental protein, while consuming low quality forages have been widespread and have provided variable results. Improved performance has been attributed to increased intake (Caton, 1988; DelCurto et al., 1990a; DelCurto et al., 1990b); increased apparent digestibility (DelCurto et al., 1990a; DelCurto et al., 1990b); increased ruminal digesta turnover (Corbett, 1981); and improved nutritional status through increased intestinal uptake of protein (Judkins et al., 1987).

Evidence that supplementation has no effect upon, or even suppresses intake, is found in Judkins et al. (1987). DelCurto et al. (1990a) provide an explanation of why apparently contradictory results are common. Response to protein supplementation is affected by the

energy status of the animal and the energy content of the supplement provided. The provision of energy, without meeting protein requirements, results in depressed forage intake due to a substitution effect (DelCurto et al., 1990a; Vanzant and Cochran, 1994).

Provision of a canola meal supplement, at four levels, to cows grazing dormant rough fescue grassland, resulted in decreased weight loss at 0.8 kg and 1.2 kg supplement day^{-1} when compared to animals receiving no supplement or 0.4 kg of supplement day^{-1} (Willms et al., 1998). Supplementation at a rate of 0.4 kg day^{-1} resulted in increased weight loss compared to animals receiving no supplement.

Soder et al., (1995) reported no significant difference in weight changes between treatments where ewes grazing dormant winter range were supplemented with isonitrogenous levels of protein. The protein supplements contained either relatively high ratios of RUDP to RDP (feather meal / blood meal) or approximately equivalent amounts of RUDP to RDP (feather meal / blood meal / urea).

2.2.2. Energy requirements

Energy requirements for various classes of animals may be calculated from the equations derived and provided by the NRC (1996) Nutrient Requirements for Beef Cattle. The net energy requirements of maintenance (NE_m) for medium framed calves weighing 220 kg to 290 kg, range from 4.1 to 5.5 Mcal day^{-1}. The net energy requirements of gain (NE_g) for calves weighing 220 kg, gaining 0.5 or 1.0 kg day^{-1}, are 1.3 and 2.7 Mcal day^{-1}, respectively. The net energy requirements of gain (NE_g) for calves weighing 300 kg, gaining 0.5 or 1.0 kg day^{-1}, are 1.7 and 3.7 Mcal day^{-1}, respectively. An increase of 10 to 20% in maintenance

energy is required for animals exposed to favorable grazing conditions (Buskirk et al., 1992; NRC 1996). Under less favorable conditions, the maintenance energy requirements for grazing animals may increase as much as 50% (Buskirk et al., 1992;)

Ewes grazing winter range in Montana displayed a similar body weight response to energy supplementation from barley as they did to isonitrogenous supplementation levels of protein supplements (Soder et al., 1995).

2.2.3. Mineral Requirements

Calcium requirements for 200 kg beef animals range from 6 to 27 g d^{-1} to meet maintenance needs and allow for growth up to 1 kg d^{-1}. Calcium requirements for 250 kg beef animals range from 8 to 25 g d^{-1} to meet maintenance needs and allow for growth up to 1 kg d^{-1} (NRC, 1996). Phosphorus requirements for 200 kg beef animals range from 5 to 11 g d^{-1} to meet maintenance needs and allow for growth up to 1 kg d^{-1} . Phosphorus requirements for 250 kg beef animals range from 6 to 10 g d^{-1} to meet maintenance needs and allow for growth up to 1 kg d^{-1} (NRC, 1996). The majority of Ca and P, 98% and 80+% respectively, are required for proper bone and teeth formation. The remaining 2% of calcium is found in the extracellular fluids and soft tissues with involvement in muscle contraction, blood clotting, nerve impulse transmission, membrane permeability, cardiac regulation, secretion of specific hormones, and the activation and stabilization of enzymes (NRC, 1996). Approximately 20% of P is located in soft tissues with a functioning role in cell growth and differentiation as a component of RNA and DNA; energy transfer and utilization through ATP, ADP and AMP; phospholipid

formation; and maintenance of acid-base and osmotic regulation. Rumen microorganisms also require phosphorus for growth and cellular metabolism (NRC, 1996).

2.3 Stockpiled Grazing

Stockpiled grazing is the grazing of forage which has been designated for use following the active growing season. Nutritional deficiencies arise in the mature forage, associated with the high fibre levels and declining protein content (Judkins et al., 1987; Minson, 1990). Forage intake may be limited due to high levels of Neutral Detergent Fibre (NDF) associated with stem elongation in mature plants. Crude protein levels decline in forages as they mature due to dilution through increased plant biomass and nutrient loss which occurs as a result of weathering. Selection of appropriate forage species for stockpiled grazing is paramount to the success of this management strategy.

Work conducted by Hitz and Russell (1998), indicated tall fescue- alfalfa pastures produced more acceptable gains than either smooth bromegrass-red clover or corn crop residues. Treatments in this work were based on grazing the regrowth on hay fields following two hay cuttings in each year of the study.

Environmental conditions in the semi-arid prairie are less favorable in terms of multiple harvesting dates for forage crops. To insure an adequate quantity of forage for extending the grazing season beyond the active growing period, pasture is required to grow during favorable conditions to be stockpiled for later use. Studies conducted previously at Swift Current, SK and Miles City, MT investigated the ability of Russian wild ryegrass to sustain animal productivity during September, October and November (Adams, 1985; Holt and Knipfel,

1993). Rough fescue (*Festuca campestris* Rydb.) has also been used to provide winter pasture for beef cattle in the northern great plains (Willms et al., 1993).

2.4 Swath Grazing

Swath grazing is a management practice which is gaining popularity among western Canadian cattle producers. Allowing animals to gather forage for themselves through a portion or all of the winter feeding period results in decreased feeding, corral cleaning and machinery costs. Annual crops, such as barley and oats, are seeded and swathed at the soft dough stage, to provide a means for grazing animals to find the forage during the winter season. Previous recommendations indicated delaying the seeding date would improve forage quality because of a reduction in time between swathing and grazing (Klein, 1996; McCartney, 1996). The theory behind this recommendation was based upon weathering effect reducing forage quality and the possibility of toxins forming from mold growth. More recent efforts have indicated seeding dates resulting in improved biomass production are more favorable than seeding dates designed to minimize the risk of mold growth and weathering effect (Klein, 1999).

2.5 Forage

2.5.1 Russian Wildrye (*Psathyrostachys junceus*)

Russian wildrye (*Psathyrostachys junceus* (Fisch.) Nevski, formerly *Elymus junceus* Fisch.) is a perennial bunchgrass which is adapted to semi-arid environments. RWR was introduced to Canada from its native location of Siberia in 1926. Leaf production is mainly basal, making RWR better suited for pasture than hay. Interest in RWR stems from the

relatively high nutritive value throughout the growing season, and into the fall and early winter (Lawrence and Heinrichs, 1977).

Stockpiled yields of RWR determined in September, over a five year period from 1983 to 1988, averaged 650 kg ha^{-1} (Holt and Knipfel, 1993). Animal production from this study indicated that lactating beef animals maintained weight while the suckling calves gained 0.95 kg d^{-1}. Daily organic matter intake of the cows averaged 2.8 % of body weight. Daily organic matter intake of the calves ranged from 1.6% to 2.3 % of BW, dependant upon IVOMD, which ranged from 54 to 63 % respectively.

Season long production of RWR averaged 3257 kg ha^{-1} over the three year period, 1989-1991 (Holt and Lawrence, 1994). Initial forage IVOMD was 68 % and declined at a rate of 0.17 % d^{-1}, corresponding to results reported by Holt et al. (1991). This production supported steer ADG of 1.0 kg d^{-1} over a grazing season commencing in May and ending in September.

2.5.2 Western Wheatgrass (*Pascopyrum smithi*)

Western wheatgrass (Pascopyrum smithi (Rydb.) A. Löve, formerly *Agropyron smithi* Rydb.) (WWG) is a rhizomatous grass, native to the Northern Great Plains. Studies by Lawrence (1977) and Kilcher and Looman (1983) indicated WWG provided 1292 and 424 kg ha^{-1}, respectively, of plant biomass annually. Crude protein content of WWG peaked in the spring and declined through the summer, falling below the protein requirements of a mature cow in early September. IVOMD analysis indicated a digestibility of 44 % (Lawrence, 1977) which is in agreement with results reported by Abougendia (1998) for a comparable time of

year. Fibre levels reported by Abougendia (1998) are 36.4% and 64.1% ADF and NDF respectively.

2.5.3 Green Needle Grass (*Nassella viridula*)

Green needle grass (*Nassella viridula*, formerly *Stipa viridula* Trin.)(GNG) is native to the Northern Great Plains. Lawrence (1977) and Kilcher and Looman (1983) reported mean annual green needle grass dry matter production of 1374 and 641 kg ha^{-1}, respectively. The levels of crude protein of green needle grass, should meet or exceed mature beef cow requirements through the course of a year (Lawrence 1977). Lawrence (1977) reports a minimum value of 9.1% CP. Contradictory monthly values reported by Abougendia (1998) indicate CP levels of green needle grass fall from 8.2 % to 4.5 %, during the period of September to October, resulting in forage which is deficient in protein. Values reported for green needle grass IVOMD are 49 % and 40% by Lawrence (1977) and Abougendia (1998), respectively. ADF and NDF values reported by Abougendia (1998) are 40% and 70%, respectively.

2.5.4 Northern Wheatgrass (*Elymus lanceolatus*)

Northern Wheatgrass (*Elymus lanceolatus* (Scribn. & Smith) Gould, formerly *Agropyron dasystachum* (Hook.) Scribn.), is a rhizomatous, sod forming grass, considered very similar, morphologically to Western wheatgrass. Northern wheatgrass is generally regarded as more drought resistant and less productive than western wheatgrass. Annual dry matter production reported by Kilcher and Looman (1983) ranged from 628 kg ha^{-1} to 820 kg ha^{-1}, averaging 746 kg ha^{-1} for a 3 year period. Lawrence and Ratzlaff (1989) indicated northern

wheatgrass production ranged from 647 kg ha^{-1} to 2711 kg ha^{-1}, resulting in average production of 1201 kg ha^{-1} over a five year period.

Crude protein content of northern wheatgrass is relatively constant in the late fall and early winter period at a level of 6.3% (Abougendia 1998), which would be of marginal quality for mature animals. IVOMD for the same period is 40% (Abougendia 1998), indicating poor quality forage. Corresponding ADF and NDF values were 40% and 67%, respectively (Abougendia 1998).

2.5.5 Barley (*Hordeum vulgare* L.)

Barley (*Hordeum vulgare* L.) is an annual, cool season, grass plant of the Poaceae family. It is the fourth most utilized cereal grain world wide, and is the second most common cereal grain grown in Canada. The major uses of barley are: as animal feed, malt, and for human consumption. The largest use of barley is for animal feed, as either grain, silage, greenfeed, or as a by-product of the brewing industry.

Limited data are available describing barley in terms of forage production (German, 1999). The data which are available, indicate high yield variability, ranging from 4,000 to 10,700 kg DM ha^{-1}. Crude protein ranged from 7.2% to 11.6% (Hingston, 1979; Juskiw et al., 1999) and dry matter digestibility (DMD) values of barley silage were 63.2% (Hingston, 1979).

2.6 Experimental Techniques

2.6.1 Estimation of Forage Yield

Quantification of forage production as weight, biomass, or yield is one of the most important characteristics of pasture vegetation (t'Mannetje, 1978; Cooke and Stubbendieck, 1986). These measurements and calculated values provide information which is useful in determination of the available feed resource, assessment of management, and in the calculation of grazing animal growth and forage utilization (t'Mannetje, 1978).

Techniques for estimating forage yield may be direct or indirect (Cooke and Stubbendieck, 1986). Direct methods require the removal of forage from a predetermined area, to represent the forage stand, in order to obtain an objective measure of herbage weight. Attempts to reduce the amount of time and labour required for direct estimation, have resulted in the development of yield prediction equations based upon variables affecting plant growth. Forage production in a semi arid environment has been highly correlated to April, May and June total precipitation (White, 1985). The linear relationship between leaf area index and biomass production has resulted in the use of various leaf canopy analysers for indirect determination of forage yield (Harmoney et al., 1997). Canopy height has also been subjected to use as a variable of biomass production (Harmoney et al., 1997). The method used to determine plant height may be as simple as recording the measurement of the tallest plant within a defined area around a ruler or it may involve the use of a modified Robel pole or a rising plate meter. The modified Robel pole has the highest correlation ($r^2 = 0.63$) to actual forage biomass and may be improved through the use of calibration equations based upon individual plant species (Harmoney et al., 1997).

The most common and accurate method for determination of forage production in research trials remains the direct clipping method. In order to allow for the production of plant biomass during grazing trials, cages or exclosures are utilized to protect a sample portion of the pasture from grazing activity. Samples are clipped from the exclosures and a similar grazed area nearby for determination of forage utilization (Cooke and Stubbendieck, 1986). During periods of minimal plant growth, samples may be clipped prior to animal turnout for determination of available yield and following animal removal for the determination of residual yield.

2.6.2 Determination of Live Weight

Animal performance is the primary indicator of a forage's ability to meet an animals nutrient requirement. Performance is frequently determined by an animal's weight or weight gain (Cooke and Stubbendieck, 1986). Factors influencing variability in an animal's weight include gut fill, time of day, and handling practices.

In order to minimize variability due to gut fill, a standard 12 hour, overnight shrink without feed or water, can be utilized (t'Mannetje, 1978; Heitschmidt, 1982; Cooke and Stubbendieck, 1986). Use of a mean weight from two consecutive days (Soder et al.,1995) reduces individual animal variation due to gut fill. This method does not require a period of shrink, and is therefore desirable when environmental conditions may be an additional cause of stress to the animal.

Day to day variation in weight was minimized when recorded 3 to 4 hours after sunrise (t'Mannetje, 1978). Further reductions in variation due to gut fill were achieved by weighing animals at the same time of day during each weigh period (Heitschmidt, 1982). The use of well

designed weighing facilities, randomization of weighing order, and proper handling techniques also aid in the minimization of weight variability (Cooke and Stubbendieck, 1986).

2.6.3 Determination of Fat Cover

Fat cover is a sink for retaining energy in times of positive energy balance, and a source of energy in periods of negative energy balance. Comparative slaughter techniques have been used to determine energy retained by animals fed different diets or managed in different manners (Blaxter, 1989). Real Time Ultrasound (RTUS) has become an accepted method for estimation of fat cover for live animals (Bergen, 1995). The use of appropriate equipment by a certified technician reduces variability and provides a quantified fat cover in the live animal. The use of a Body Condition Score (BCS) provides an estimation of animal condition which is subject to interpretation by the individual taking the measurements (Rutter et al., 1992).

2.6.4 Time Spent Grazing

Visual observation may be used to determine various aspects of animal behaviour, such as time spent grazing, ruminating, drinking and sleeping. The labourious nature of this time consuming task, along with the difficulties associated with making visual observations in the dark of night, led to the development of automated vibracorders. Recorders are manufactured by Kienzle in Germany and by the Sycon Corporation of Ohio and consist of a freely moving pendulum, connected to a recording stylus which scribes a waxed chart on a rotating clock mechanism when the animal lowers its head (Popp, 1996; Walker and Heitschmidt, 1989).

2.6.5 Intake Estimation

Intake of grazing animals may be determined externally through the disappearance of herbage or by short term liveweight changes. Intake estimation may be made internally utilizing fecal index techniques (Minson, 1990; Adams et al., 1991). Determination of the digestibility of the consumed forage is a requirement of fecal index techniques. Digestibility can be determined collecting extrusa from esophageally fistulated animals (Langlands, 1975; 1987) or by the hand plucking method (Wallis de Vries, 1995). The addition of an indigestible marker, such as chromic oxide, is required for the determination of fecal output. Fecal output is calculated in the equation:

$$\text{Fecal output (kg)} = \frac{\text{Daily intake of } Cr_2O_3 \text{ (g)}}{\text{Concentration } Cr_2O_3 \text{ of grab samples (mg/g)}} \qquad \text{Equation 2.1}$$

Intake may then be calculated from the equation:

$$\text{Intake} = (\text{Fecal Output})/(1\text{-Digestibility}) \qquad \text{Equation 2.2}$$

Chromic oxide may be administered daily or for extended periods through the use of a slow release, intraruminal device (Ellis et al., 1981; Adams et al., 1991). The use of calibration curves based on feces from animals grazing the same forage stand reduce the variation and increase the accuracy of intake estimation based on low levels of chromium in the feces (Holt, 1992).

2.7 Quality Estimation

2.7.1 Crude Protein

The Kjeldahl method of nitrogen quantification (AOAC 1990 method no. 984.13) is commonly utilized to determine crude protein (CP) where:

$$CP = (Kjeldahl\ N) \times 6.25 \qquad \text{Equation 2.3}$$

By definition, CP includes true protein, rumen degradeable protein (RDP), rumen undegradeable protein (RUDP), and non-protein nitrogen (NPN).

2.7.2 Fibre Analysis

Analysis of forage fibre is a valuable tool for developing an understanding of the degree and rate of digestion of fibre in the rumen. Neutral Detergent Fibre has been negatively correlated with feed intake while acid detergent fibre has been correlated with the energy content of forages.

2.7.2.1 Neutral Detergent Fibre (NDF)

NDF is composed of hemi-cellulose, cellulose, lignin and fibre bound nitrogen. Determination of NDF is usually conducted according to the methods described by Van Soest et al. (1991).

2.7.2.2 Determination of Acid Detergent Fibre (ADF)

The major components of ADF are cellulose, lignin and silica. Determination of ADF is usually conducted according to AOAC 1990 Method No.973.18. as an estimate of energy

which may be derived from the fermentation of fibre in the rumen.

2.7.3 Organic Matter Digestibility

2.7.3.1 *In vitro* Organic Matter Digestibility (IVOMD)

Estimates of forage digestibility are used as indicators of forage quality and are required for calculations in the estimation of feed intake. The most common procedure utilized is a two stage technique developed by Tilley and Terry (1963). The first stage of the procedure involves digestion of 0.5 g of sample in rumen fluid and buffering solution for 48 hours at 38 °C. Microorganism growth is subsequently checked with $HgCl_2$, and centrifuged. Supernatant is removed and a pepsin solution is added prior to another 48 hour digestion at 38 °C. Modifications to the procedure have been made by Troelsen (1970) and have since been adopted. These modifications include the use of HCl for checking microorganism growth by reducing the pH to 1.2. The second stage of the digestion is shortened to 24 hours and filtration is used to recover the residue for determination of organic matter disappearance.

2.7.3.2 *In situ* Digestibility

Employment of a ruminally fistulated animal allows the placement of a nylon or polyester bag, containing a feed sample, into the rumen environment. Digestibility of the feed sample contained within the bag is calculated from the reduction in weight of the bag as a result of feed disappearance. This technique is useful in determining rates of degradation of feed ingredients. Factors affecting *in situ* analysis are varied and have been reviewed by Nocek (1988).

2.7.4 Mineral Analysis

Calcium and phosphorus content are usually determined according to AOAC methods NO. 965.09 and NO. 978.01, respectively.

2.7.5 Fecal Chromic Oxide Analysis

Digestion of fecal material for analysis of low levels of chromic oxide may be conducted through the use of perchloric acid (Kimura and Miller, 1957), phosphoric acid and potassium bromate (Christian and Coup, 1954), or fusion with sodium peroxide and sulfuric acid (Fisher et al., 1972). The use of Controlled Release Capsules (CRC) for dosing animals results in extremely low levels of chromic oxide in the feces, requiring more sensitive procedures to be developed. Holt (1992) developed a procedure based on that of Kimura and Miller (1957), employing the use of perchloric acid to digest organic matter prior to the addition of sodium molybdate. Feces from an undosed animal in the same treatment were digested for use in the determination of calibration curves. The formation of the calibration curves, allows adjustments for interference caused by the feces when using atomic absorptive spectrophotometry.

Challenges related to the use of mature, standing forage, by weaned beef calves have been reviewed in order to develop alternative backgrounding systems for use in south western Saskatchewan. The remainder of this thesis contains data from two experiments conducted at the Semi-arid Prairie Agricultural Research Centre to determine the applicability of stockpiled grazing for fall backgrounding activity and extension of the grazing season for mature animals.

Chapter 3

Performance of Cow/Calf Pairs and Weaned Calves Grazing Russian Wild Ryegrass

3.1 Introduction

Grazing is the most economical method of feeding the beef animal. Methods which extend the grazing season can result in improved profitability by reducing feed costs (Adams et al., 1994). Providing forage of adequate quantity and quality for maintenance and growth of young animals at the end of the growing season presents a challenge in a semi-arid environment. Russian wild ryegrass (*Psathyrostachys junceus* (Fisch.) Nevski, formerly *Elymus junceus* Fisch.)(RWR) is a forage grass species which can be successfully stockpiled to provide a relatively high quality pasture for the fall grazing season (Lawrence and Heinrichs 1977; Holt 1996) in the semi-arid region of southwestern Saskatchewan.

At the same time as beef cow-calf producers are interested in extending the fall grazing period, they are also faced with making decisions about when to wean their calves. Reductions in herd fertility have been associated with delayed weaning because body condition is reduced during lactation (Rutter et al., 1992). As with any other decision in agricultural production, weather plays an important role. The onset of cold weather at weaning may increase the incidence of health problems. Most producers choose to wean their calves in the drylot, providing hay and grain, while others may use pastures for weaned calves. The timing and amount of growing season precipitation has a direct impact on the available forage for fall grazing (White, 1982).

The objective of the present study was to determine the ability of Russian wild ryegrass to maintain or increase the liveweight of weaned beef calves late in the grazing season, in comparison to delayed weaning or drylot feeding of weaned calves.

3.2 Materials and Methods

3.2.1 Study Site

The study was conducted at the Semi-arid Prairie Agricultural Research Centre (SPARC), Agriculture and Agri-Food Canada, Swift Current, Saskatchewan, latitude 50°16', longitude 107° 44', during the fall and winter of 1997 and 1998. The pastures were established prior to this study and contained Russian wild ryegrass in a 30 cm row spacing or Russian wild ryegrass on 30 cm rows with meadow bromegrass (*Bromus riparius*)(BG) seeded between the rows of Russian wild ryegrass. Due to the creeping nature of brome grass, the area between the rows of Russian wild ryegrass had filled in.

All the pastures were located on the same parcel of land which is described as having a Chernozemic orthic brown soil, of the Haverhill loam association, on a gently rolling topography (Saskatchewan Soil Survey, 1992). The drylot, constructed from 20% porosity fencing, was located on this same parcel of land. It was used to house the animals in the control treatment. Environmental data were obtained from the SPARC weather centre and are reported in Tables A.1 - A.5 of Appendix A.

The RWR/BG pasture grazed by weaned calves was 3.1 ha in size while the cow-calf pairs were allotted 8.1 ha of Russian wild ryegrass pasture. Different pasture sizes were used in an attempt to provide equivalent stocking rates in each pasture.

3.2.2 Animal and Grazing Management

Animals were selected from the Hereford and Hereford x Angus herd maintained and managed by SPARC for the Horned Cattle Trust Fund. The calving season at SPARC is six weeks, beginning the third week of February and ending the first week of April. Animal availability was determined in the first year based on maternal status prior to weaning. Calves belonging to dams which were going to be culled were excluded. The resulting 36 pairs were allocated to one of three treatments based on equivalent distribution of calf weight among treatments.

The three treatments for this experiment were; 1) calves were weaned and placed on 3.1 ha of RWR/BG (WEAN),resulting in a stocking density of 2.3 AU ha^{-1}; 2) calves remained with dams on 8.1 ha of Russian wild ryegrass pasture (PAIR), equivalent to a stock density of 2.9 AU ha^{-1}, and were weaned at the conclusion of the study; or 3) calves were weaned and placed in drylot (DRYLOT). An animal unit (AU) is defined as a mature 455 kg cow or equivalent. In 1997, the dams of weaned calves were returned to native grass pastures and were unavailable for biweekly weighing and collection of ultrasound data. In 1998, they were placed on another Russian wild ryegrass pasture.

Grazing commenced October 6 and ceased on November 26 in 1997, resulting in 52 days on test. Supplemental hay was required by the PAIR treatment in both years of the study in order to maintain body condition of the animals. Feeding of supplemental hay to PAIR treatment commenced 7 days prior to the end of test. In 1997, 2418 kg of grass hay was offered, equivalent to 28.8 kg d^{-1} of the supplemental feeding period for each cow-calf pair. In 1998, grazing began October 13 and ended November 10, providing 29 days on test. Feeding

of supplemental hay to PAIR treatment commenced 5 days prior to the end of test. In 1998, 2064 kg of grass hay was offered, equivalent to 34.4 kg d^{-1} of the supplemental feeding period for each cow-calf pair. The study period was ended when two observers agreed, following visual assessment, that the amount of available forage in the WEAN treatment pasture had been reduced to the desired level of utilization. The shortened grazing period in 1998 compared to 1997 was a result of reduced forage production. The drylot ration consisted of alfalfa /grass hay fed ab libitum and an average of 2.5 kg d^{-1} of ground barley. The ground barley was provided at lower levels initially (1.8 kg d^{-1}) and over the course of the study was gradually increased to 3.5 kg d^{-1}.

Water was provided to all animals via heated water bowls. Salt and mineral supplements containing calcium and phosphorus in a 1:1 ratio, as well as trace minerals, were provided free choice through the duration of the study. Animals were handled in accordance to the Canadian Council of Animal Care guidelines at all times. In 1998, one animal was removed from the drylot treatment due to the occurrence of frothy bloat.

3.2.3 Field Methodology

Initial and final animal weights were determined by weighing individual animals on two consecutive days and averaging the weights to minimize variability due to gut fill (Soder et al.,1995). Animals were weighed biweekly to monitor progress. Ultrasonic backfat was measured at the commencement and conclusion of the study by a certified technician using an Aloka 500V diagnostic Real Time Ultra Sound (RTUS) unit equipped with a 17 cm, 3.5 MHz, linear array transducer as described by Bergen (1997). Final real time ultra sound back fats

were measured within five days of the end of the study. In 1997, the weights and real time ultra sound back fats of the cows were not monitored because cows which had their calves removed were moved to a remote location to be turned out on native mixed grass prairie. Cow weights and real time ultra sound backfats were collected in 1998 for all dams of calves in the study.

Intakes for the DRYLOT animals were determined by averaging the total amount of feed provided to the treatment over the course of the study. Feed:Gain ratios were calculated based on intake data. Grazing calf intakes were estimated during the second year of the trial using controlled release chromic oxide boluses. Fecal organic matter output of the calves was determined by dosing 3 calves per treatment with a controlled release chromic oxide bolus (Captec (NZ) Ltd.). The release rate of the bolus was 1.72 g of chromic oxide per day as determined by the manufacturer. Following a seven day equilibration period, fecal grab samples were obtained from the bolused animals and one animal which was not bolused for each treatment, on three consecutive days. Fecal samples were frozen following collection and were then dried in forced-draught ovens at 50°C for 120 hours. Samples were then ground in a Thomas-Wiley mill to pass a 1mm screen and stored in glass vials at room temperature.

Available and residual forage yields were determined by clipping 16, 0.25 m^2 random quadrats per paddock to a 3 cm height, prior to commencement of grazing and following removal of animals. In addition to available and residual yields, samples for quality analysis were hand plucked biweekly (Cooke and Stubbendick,1986; Wallis de Vries, 1995). In preparation for laboratory analysis, all forage samples were dried in a forced-draught oven at 50 °C for 48 hours. Samples were then weighed for yield determination and ground through a 1mm screen in a Thomas-Wiley mill. Samples were maintained in glass vials at room

temperature following grinding until laboratory analysis could be performed.

3.2.4 Laboratory Analysis

All samples were dried in a vacuum oven at 65 °C overnight prior to analysis. *In vitro* organic matter digestibility (OMD) of forage samples was determined by the procedures of Tilley and Terry (1963) as modified by Troelson (1969). Crude protein (CP) was represented by N x 6.25 as determined by the Kjeldahl procedure (AOAC no. 984.13, 1990). Phosphorus concentration was determined by AOAC method No. 965.09. Fecal chromic oxide concentration was determined by the method of Kimura and Miller (1957) as modified by Holt (1992). Fecal organic matter output was estimated from the equation:

$$\text{FOM} = \text{fecal } [Cr_2O_3] / \text{daily } Cr_2O_3 \qquad \text{Equation 3.1}$$

Where FOM = fecal organic matter output

Fecal $[Cr_2O_3]$ = fecal chromic oxide concentration (mg kg^{-1})

Daily Cr_2O_3 = Cr_2O_3 provided by controlled release capsule=1.72 g day^{-1}

Organic matter intake (OMI) was calculated from the equation:

$$\text{OMI} = (\text{FOM})/(1\text{-OMD}) \qquad \text{Equation 3.2}$$

Where OMI = organic matter intake

FOM = estimated daily fecal organic matter output

OMD = *in vitro* organic matter digestibility

Daily feed intake of animals in the drylot was calculated from the total amount of feed using the equation:

feed intake = kg of feed provided / (# of animals in pen x days of trial) **Equation 3.3**

Neutral Detergent Fibre (NDF) was determined by methodology derived by Van Soest et al. (1991). Acid Detergent Fibre (ADF) was determined according to AOAC method No. 973.18 (1990).

3.2.5 Statistical Analysis

The experiment was a completely random design with individual animals as the experimental units (Caton et al., 1988; Soder et al., 1995). Data from each year were analysed separately using the General Linear Models Procedure for analysis of variance (SAS Institute, 1996). Significant differences ($P<0.05$) in treatment means, as indicated by a significant F-test, were separated using the Least Significant Difference procedure (SAS Institute, 1996). Backfat data were analysed for possible correlation between change in backfat and average daily gain using the Pearson's Correlation. Feed intake data for calves on pasture were analysed using the repeated measures procedure of SAS. Significant differences ($P<0.05$) in feed intakes were separated using the Least Significant Difference procedure (SAS Institute, 1996).

3.3 Results

3.3.1 Animal Performance

Average daily gain of weaned calves grazing Russian wild ryegrass was significantly lower ($P<0.05$) than that of the drylot calves or the unweaned calves in 1997 (Table 3.1). Differences in ADG ($P<0.05$) were evident between all three treatments in 1998 (Table 3.2) with WEAN calves gaining the least weight and DRYLOT calves gaining the most weight. Final backfat thickness in 1997 was greatest for Drylot calves and PAIR calves on pasture but least for WEAN calves on pasture (Table 3.1). However, there was no difference in the change in backfat during 1997. Therefore, the significant difference observed in the final backfat was related to unintentional differences in initial backfat. In 1997, calves gaining 0.2 kg d^{-1} exhibited a 0.2 mm increase in backfat while in 1998 calves gaining 0.6 kg d^{-1} exhibited a 0.3 mm decrease in backfat. Correlations between ADG and ΔBF were small and not significant (Table 3.6). Data from 1998 (Table 3.4) indicate that delaying weaning while grazing stockpiled Russian wild ryegrass had no significant effect on cow liveweight or backfat.

Feed intake of the calves in the PAIR treatment would have included milk intake. The milk production from beef animals at the end of lactation would be greatly reduced but it would provide a highly digestible supplement to complement the grazed forage. Due to the differences in methodology for determination of intakes, it would be inappropriate to compare the grazing animal intakes to the drylot animal intakes. Statistical analysis of the grazing animal intakes revealed no significant difference as reported in Table 3.5.

Drylot cost of gain was established based on known feed costs and a yardage charge of $0.30 per head per day. Pasture cost was based on $1.25 per cow/calf pair equivalent per day.

Table 3.1. Initial weight, final weight, ADG, final ultrasound backfat depths and change in backfat for calves at SPARC from Oct. 6/97 to Nov. 26/97.

	DRYLOT	WEAN	PAIR	SEM[w]
Initial weight (kg)	240	244	242	12
Final weight (kg)	282	268	280	15
ADG[x] (kg d^{-1})	0.3[a]	0.2[b]	0.3[a]	0
Final BF[y] (mm)	3.5[a]	2.1[b]	3.2[a]	0.2
Δ[z] BF (mm)	1.1	0.3	0.7	0.4

Means within a row, followed by different letters are significantly different as tested by LSD at α=0.05
w=standard error of the mean; x=average daily gain; y=back fat; z=change in

Table 3.2. Initial weight, final weight, ADG, final ultrasound backfat depths and change in backfat for calves at SPARC from Oct. 13/98 to Nov. 10/98.

	DRYLOT	WEAN	PAIR	SEM[w]
Initial weight (kg)	264	259	270	14
Final weight (kg)	293	275	294	15
ADG[x] (kg d^{-1})	1.0[a]	0.6[c]	0.9[b]	0.1
Final BF[y] (mm)	3.3	3.4	2.8	0.8
Δ BF[z] (mm)	0.6	-0.3	0.3	1

Means within a row, followed by different letters are significantly different as tested by LSD at α=0.05
w=standard error of the mean; x=average daily gain; y=back fat; z=change in

Table 3.3. Estimated cost of gain ($ kg^{-1}) associated with backgrounding activity at SPARC in 1997 and 1998.

Year	DRYLOT	WEAN	PAIR
1997	2.65	2.50	2.17
1998	1.06	0.75	1.34

Table 3.4.Initial weight, final weight, ADG, final ultrasound backfat depths and change in backfat for cows of calves at SPARC from Oct. 13/98 to Nov. 10/98.

	DRYLOT	WEAN	PAIR	SEM[w]
Initial weight (kg)	617	617	608	32
Final weight (kg)	627	627	611	33
ADG[x] (kg d^{-1})	0.4	0.4	0.1	0.2
Final BF[y] (mm)	5.2	4.8	4.9	1.6
Δ^z BF (mm)	1	0.1	-0.2	0.7

Means within a row, followed by different letters are significantly different as tested by LSD at α=0.05
w=standard error of the mean; x=average daily gain; y=back fat; z=change in

Table 3.5. Estimated mean intakes and calculated feed: gain ratios of calves in 1998.

	DRYLOT	WEAN	PAIR	SEM
Intake (kg/d)	7.3	6.2	5.9	0.4
Feed : Gain	7.3	7.3	10.7	–

1. Intake calculated according to equation 3.1

Table 3.6. Correlation coefficients and probabilities for average daily gain in relationship to the change in backfat for calves among all treatments in 1997 and 1998.

	Calves		Cows
	1997	1998	1998
r	0.27	-0.31	0.27
P	0.11	0.07	0.12

3.3.2 Forage Characteristics

Forage yields for the study are reported in Table 3.7. Forage dry matter production was greater in 1997 than in 1998 due to more favourable precipitation in the early spring and

summer (Table A.1). Utilization was less in 1997 than in 1998 but was consistent within year across the PAIR and WEAN pasture treatments.

Data for quality of available forage are found in Tables 3.8 and 3.9, for the years 1997 and 1998, respectively. In 1997, forage quality of the WEAN and PAIR treatment pastures were similar (Table 3.8). The feed provided to the DRYLOT animals was higher in CP, P and OMD and lower ADF and NDF than the pasture treatments. Despite these differences in forage quality, the ADG of the DRYLOT treatment was similar to the WEAN treatment. In 1998, the OMD of the PAIR treatment pasture was less than the OMD of the WEAN pasture (Table 3.9). The OMD of the hay in the DRYLOT treatment was lower than expected based on ADF, NDF and CP content (Table 3.9). Given the ADG values observed for the DRYLOT and PAIR treatments (Table 3.2), the OMD values observed in 1998 are contrary to animal performance. The OMD procedure is sensitive to technique and these values may have underestimated *in vivo* digestibility.

Table 3.7. Available and residual yields of pastures provided in 1997 and 1998.

Year	Treatment	Available (kg ha^{-1})	SEM[z]	Residual (kg ha^{-1})	SEM[z]	Utilization %
1997	WEAN	2243	143	742	70	67
1997	PAIR[1]	3065	169	920	93	70
1998	WEAN	1544	171	311	47	80
1998	PAIR[2]	1598	126	306	52	80

z=standard error of the mean; 1. Provided with 2418 kg of supplemental hay; 2. Provided with 2064 kg of supplemental hay.

Table 3.8. Quality parameters of available Russian wild ryegrass pasture and feed provided to animals in the drylot at SPARC in 1997.

	RWR				DRYLOT			
	WEAN	SEM[t]	PAIR	SEM	Hay	SEM	Grain	SEM
OM[u] (g kg^{-1})	930	2	930	2	915	1	946	22
OMD[v] (g kg^{-1})	515	6	498	8	639	6	796	73
ADF[w] (g kg^{-1})	385	3	383	3	331	9	941	1
NDF[x] (g kg^{-1})	665	5	678	5	410	11	235	12
CP[y] (g kg^{-1})	78	7	69	6	182	4	113	11
TP[z] (g kg^{-1})	1.5	0.1	1.4	0.01	2.	0.01	3.7	0.01

t=standard error of the mean; u=organic matter; v=organic matter digestibility; w=acid detergent fibre; x=neutral detergent fibre; y=crude protein; z=total phosphorus

Table 3.9. Quality parameters of available Russian wild ryegrass pasture and feed provided to animals in the drylot at SPARC in 1998.

	RWR				DRYLOT			
	WEAN	SEM[t]	PAIR	SEM	Hay	SEM	Grain	SEM
OM[u] (g kg^{-1})	916	3	923	11	925	20	944	22
OMD[v] (g kg^{-1})	522	9	465	27	479	26	793	73
ADF[w] (g kg^{-1})	344	24	348	25	367	8	941	1
NDF[x] (g kg^{-1})	633	26	636	27	548	10	233	12
CP[y] (g kg^{-1})	131	19	133	20	137	4	109	11
TP[z] (g kg^{-1})	1.8	0.3	1.8	0.3	2	0.01	3.4	0.01

t=standard error of the mean; u=organic matter; v=organic matter digestibility; w=acid detergent fibre; x=neutral detergent fibre; y=crude protein; z=total phosphorus

3.3.3 Carrying Capacity

In 1997, the carrying capacity of Russian wild ryegrass was 3.7 AUM ha^{-1} or 113 AGD ha^{-1} and 4.2 AUM ha^{-1} or 129 AGD ha^{-1} for the WEAN and PAIR pastures respectively. Carrying capacity of the WEAN and PAIR pastures was 2.2 AUM ha^{-1} or 66 AGD ha^{-1} and 2.3 AUM ha^{-1} or 70 AGD ha^{-1}, respectively, in 1998.

3.4 Discussion

Animal performance in the current study was lower in 1997 than previously reported by Holt and Knipfel (1992) who had indicated an ADG of 0.95 kg d^{-1} for unweaned calves grazing Russian wild ryegrass in the fall. Forage quality, especially crude protein content (70-80 g kg^{-1} in 1997 vs 120-130 g kg^{-1} in 1998), may be responsible for the differences seen in animal performance in 1997 (Table 3.1) in comparison to the previous studies. Results reported in Table 3.4 confirm the maintenance of weight in the mature, lactating, cows grazing stockpiled Russian wild ryegrass reported by Holt and Knipfel (1992).

Average daily gain exhibited a similar pattern among treatments for both years. DRYLOT average daily gain was greater than PAIR average daily gain, though only significantly different ($P<0.05$) in 1998. Both treatments provided significantly greater average daily gain ($P<0.05$) than the WEAN calves grazing Russian wild ryegrass in both years. The higher crude protein levels in 1998 contributed to the improved calf average daily gain in both the WEAN and PAIR treatments in comparison to the average daily gain exhibited by the calves in 1997. The response in ADG of the PAIR calves relative to the DRYLOT calves which

received a better quality diet, is most likely due to the milk the PAIR calves received behaving as a highly digestible supplement complementing the poorer quality forage.

Additional variation in average daily gain between years may have also been caused by the shorter time frame. Greater weight variation due to gut fill could have influenced the observed weight gains. Slightly warmer temperatures experienced by the animals as a result of the shortened time frame in 1998 may have reduced the maintenance energy required, thereby providing more energy for tissue gain. These effects are possible explanations for differences seen in average daily gain of the DRYLOT animals which had lower rates of gain in 1997 on higher quality forage (CP=182 and OMD=639 vs. CP=137 and OMD=479 g kg^{-1}) than in 1998. Another possibility for the depressed performance of the DRYLOT animals in 1997 is that the rapid digestion of high quality hay may have resulted in the development of chronic acidosis.

Quantity and quality of available forage are the primary determinants of ruminant intake and production. Production of adequate forage for stockpiled grazing in the semi-arid prairie requires the entire growing season due to limited moisture availability. Strong correlations have been made between dry matter production and spring precipitation in the semi-arid prairie (White, 1985). Although April through June precipitation was roughly equivalent for both years, nearly half of the precipitation in 1998 arrived after the third week of June. This relatively dry spring resulted in reduced herbage production compared to 1997.

No nitrogen fertilizer was applied to these pastures so CP levels reflected nitrogen mineralization from soil organic matter. Higher forage dry matter production in 1997 likely

resulted in the dilution of the nitrogen content of the forage compared to 1998. This is reflected in the lower CP values observed in 1997 vs 1998. While Holt (1996) does not recommend nitrogen fertilization of RWR pastures in the semi-arid prairie due to weather risk or uncertainty of precipitation, it may be necessary for improved CP content, particularly in years with early spring precipitation. The use of supplemental dietary CP may be another alternative to N fertilization to increase CP intake of animals grazing stockpiled RWR.

Forage production in the current study was higher than long term data (Lawrence and Heinrichs, 1977) reported for Russian wild ryegrass. The 1997 growing season was exceptional with forage production exceeding 3000 kg/ha while the nine year average production reported by Lawrence and Heinrichs (1977) was 1008 kg/ha. Russian wild ryegrass production in 1998 was closer to the long term average, at 1598 kg/ha. As a result of reduced forage availability, carrying capacity of WEAN pasture fell to 70% of 1997 and the PAIR pasture carrying capacity fell to 52% of 1997 levels. Fall precipitation was more prevalent in the fall of 1998, with higher levels of crude protein because the plants had returned to an active state of growth.

Statistical analysis of grazing animal intakes revealed no significant differences in intake. Feed intake of the calves in the PAIR treatment included milk intake, but no estimate of milk intake was made. The milk production from beef animals at the end of lactation would be greatly reduced but the milk would provide a highly digestible supplement to complement the grazed forage. The end result of the milk intake was improved animal performance as reflected in the average daily gain. Determination of intake in the DRYLOT treatment was made from direct measurement of feed provided over the course of the study. It would have been

inappropriate to have analysed DRYLOT intake with the other two treatments because of the difference in development of intake estimates.

Change in backfat results indicate that the DRYLOT and PAIR animals were generally in a positive energy balance. The change in backfat numbers for the WEAN calves indicate that energy was probably not the factor limiting growth in 1997, but may have been the limiting factor in 1998 as fat stores were mobilized to support growth. The limited quantity and range of data contributed to the non significance of backfat results and correlations between ADG and backfat.

Delaying weaning has been associated with reductions in herd fertility related to loss of dam body condition due to the extended lactation period (Rutter et al., 1992). The evidence provided by this study indicated that delayed weaning did not have an effect on rebreeding efficiency because the dams maintained or improved body condition while grazing Russian wild ryegrass. Reproductive data are not reported due to the small number of animals used in each treatment.

3.5 Conclusion

The current study is in agreement with previous studies (Lawrence and Heinrichs, 1977; Holt and Knipfel, 1992) stating Russian wild ryegrass provides a good to excellent fall pasture for beef animals. The drylot is considered the standard industry backgrounding approach for weaned calves in the fall because the quantity and quality of the feed can be controlled to provide predictable ADG. The use of Russian wild ryegrass pasture for backgrounding weaned

calves provides an alternative to challenge this paradigm, especially in regions of limited snow cover and where low ADG during the backgrounding period is economically desirable.

Delayed weaning while maintaining or increasing dam weights late in the fall was possible on stockpiled Russian wild ryegrass. The PAIR calves continued to make modest weight gains at a cost per kg of gain of $2.17 in 1997, and$1.34 in 1998. This is in comparison to a cost of gain per kg of $2.50 and $0.75 for the WEAN animals or $2.65 and $1.06 for DRYLOT in1997 and 1998, respectively. The dams' milk production would have declined, but the milk provided would likely be an excellent feed supplement. However, there may be possibilities to provide alternative feed supplements more economically.

Placement of weaned calves on Russian wild ryegrass in the fall contains many positive aspects. Average daily gains made by these animals were acceptable for the production of animals to be placed on grass as yearlings. The possibility of lowering the cost of gain when these animals are placed in the drylot through compensatory gain may provide producers with additional incentive when making the decision to provide Russian wild ryegrass pasture. The possibility of providing an appropriate supplement to increase animal performance on Russian wild ryegrass pasture requires further investigation.

Chapter 4

Performance of Steer Calves Under Stockpiled Grazing, Swath Grazing and Standard Management Systems

4.1 Introduction

Successful extension of the grazing season results in improved profitability for the cow/calf producer through reduced feed costs(Adams et al., 1994; Saskatchewan Agriculture and Food, 2000). Understanding the requirements of the grazing animal is essential for the development of appropriate grazing management systems, especially in the fall when plant are no longer actively growing and quality is declining. To support growth, weaned calves require higher levels of crude protein and energy than dry cows (NRC, 1996). Generally, grass exceeds these requirements until mid June after which declining forage quality will produce nutritional deficiencies.

Animals compensate for declining forage quality through increased selectivity of plant parts containing higher nutritional value than the nutritional value of the total available forage(Popp et al., 1999). In order to meet nutritional requirements from fall grazing activity, an appropriate species of grass should be selected. Results from previous research at SPARC suggested that western wheatgrass cures well on the stem to provide forage of adequate quality for weaned calves (Jefferson et al., 1997). However, Lawrence (1977) indicated that western wheatgrass (*Pascopyrum smithii*)(WWG) had a CP of 6.5% and an OMD of 47% in the fall, which would be inadequate for growing beef animals.

Animal performance on pasture is affected by the quantity and quality of available

forage. In a semi-arid environment, forage yield is highly correlated with precipitation, especially precipitation received in April, May and June (White, 1982). Plant quality is a function of the grass species and the stage of maturity.

The objective of this study was to determine the performance of weaned beef calves when grazing stockpiled western wheatgrass and native mixed grass (NMG) (western wheatgrass, northern wheatgrass (*Elymus lanceolatus*)(NWG) and green needle grass (*Stipa viridula*)(GNG)) and swathed barley compared to animals fed in a drylot.

4.2 Materials & Methods

4.2.1 Study Site

The study was conducted at the Semi-arid Prairie Agricultural Research Centre (SPARC), Agriculture and Agri-Food Canada, Swift Current, Saskatchewan, during the fall and winter of 1997/98 and fall of 1998. The pastures were established prior to this study and contained the various grass species. In 1997, Western wheatgrass was used in this study. In 1998, a native mixed sward of western wheatgrass, northern wheatgrass and green needle grass was grazed in addition to the pure western wheatgrass pasture. The pastures were stockpiled each year through the absence of grazing activity prior to the commencement of this study. An annual crop of barley (*Hordeum vulgare*, cv. Bonanza) was seeded in the spring of both years of this study for use in determination of the suitability of barley swath grazing (BSG) for weaned calves.

All the pastures were located on the same parcel of land which is described as having a Chernozemic orthic brown soil, Haverhill loam, on a gently rolling topography (Saskatchewan

Soil Survey, 1992). The drylot, constructed from 20% porosity fencing, was located on this same parcel of land. It was used to house the animals in the forage fed and forage fed plus grain treatments. Environmental data were obtained from the SPARC weather centre and are reported in Tables A.1-A.5 of Appendix A.

In the first year of this study, 3.0 hectares of WWG pasture was utilized from October 27 to January 7, 1998. Control treatments were based on ad libitum alfalfa hay (FF), or 3.6 kg of barley per head per day in addition to ad libitum access to alfalfa hay (GF). The animals swath grazing barley used 4.2 ha during the 73 day grazing period from October 27 to January 7. In 1998 both grass pastures were subdivided along their length to create 2, 1.5 ha paddocks of WWG and NMG, respectively. The BSG pasture was treated as a single field until after it was swathed, at which time it was split into 2, 3.6 ha paddocks. Animal access to the barley swaths was limited to three or four days of forage at a time, through the use of an electric cross fence to strip graze the field in both years.

4.2.2 Animal and Grazing Management

Hereford or Angus steers were purchased from the local stockyards during the fall of each year for use in this study. The steers were processed and placed in drylot pens on a receiving ration of long stem hay. After a period of one week, during which time the animals were closely monitored for signs of illness related to weaning and shipping stresses, animals were weighed on 2 consecutive days to establish initial weights (Soder et al., 1995) and allocated to treatment. The WWG pasture, forage fed drylot(FF) and the grain fed drylot(GF) treatments each received 15 steers, while the swath grazing treatment received the remaining

32 steers in the 1997 season. The animals were placed in their respective treatments on 27 October and were removed when the steers grazing western wheatgrass had depleted their available forage on 7 January, 1998. Final weights were also determined by averaging weights from two consecutive days.

Results from the 1997 season indicated that WWG and BSG were unable to meet the nutritional demands of the steers for growth. The addition of supplemental CP and energy to these treatments was done in an attempt to increase gains from stockpiled forage in 1998. The supplement was made by pelleting 490kg barley, 490 kg canola meal and 20 kg of tallow per tonne. Supplement was provided at a rate of 1 kg per head daily at approximately 2:00 in the afternoon, to minimize disruption of the normal grazing pattern (Adams, 1985).

Another group of Hereford calves were purchased in the fall of 1998 and were allocated to all treatments in groups of ten. In order to minimize the variability due to environmental conditions, it was necessary to have a control group for each pasture type which were unsupplemented and whose results could be compared to results from the previous year. The native mixed grass (NMG) pasture and supplement (+S) treatments were added in 1998 resulting in the following 8 treatments: GF, FF, WWG, WWG + S, NMG, NMG + S, BSG, and BSG + S. Grazing commenced October 19, 1998 and ended November 17, 1998, providing 30 days on test.

Water to all animals was provided via heated water bowls. Salt and mineral supplements containing calcium and phosphorus in a 1:1 ratio, as well as trace minerals, were provided free choice through the duration of the study. Animals were handled in accordance to the Canadian Council of Animal Care guidelines at all times. In 1998, an animal in the GF

treatment died and a necropsy was performed to verify the cause of death as bloat.

4.2.3 Field Methodology

Initial and final animal weights were determined by weighing individual animals on two consecutive days and averaging the weights to minimize variability due to gut fill (Soder et al., 1995). Animals were weighed biweekly to monitor progress and body condition. Ultrasonic backfat was measured using an Aloka 500V RTUS machine, with a 3.5 MHz, 17 cm transducer, by a certified technician (Bergen,1995).

Feed intake for drylot treatments were ascertained from direct measurement of feed provided. Fecal organic matter (FOM) output and forage organic matter digestibility (OMD) were used to estimate grazing animal intake in 1998. Fecal organic matter was determined by dosing 3 animals per treatment with a slow release chromic oxide bolus (Captec (NZ) Ltd.). Following a seven day equilibration period, fecal grab samples were obtained from each bolused animal and one animal which was not bolused for each treatment on three consecutive days. A second set of fecal grab samples were obtained two weeks later. Fecal samples were frozen following collection and were then dried in forced draught ovens at 50°C for 48 hours. Samples were then ground in a Thomas-Wiley mill to pass a 1mm screen and stored in glass vials at room temperature.

One animal from each treatment was fitted with a grazing clock in 1998 to determine the average time spent grazing in each treatment (Johnstone-Wallace and Kennedy, 1944; Hancock and McMeekan, 1954; Stobbs, 1973; Chambers et al., 1981). The grazing clocks (Kienzle, Germany and the Sycon Corporation, Ohio) consisted of a freely moving pendulum

attached to a recording stylus which scribed a mark on a waxed chart rotated by a clock mechanism when an animal lowered its head.

Available and residual forage yields were determined by clipping 16, 0.25 m^2 random quadrats per paddock to a 3 cm height. In addition to available and residual yields, samples for quality analysis were hand plucked biweekly (Cooke & Stubbendick, 1986; Wallis de Vries, 1995). In preparation for laboratory analysis, all forage samples were dried in a forced-draught oven at 50°C for 48 hours. Samples were then weighed for yield determination and ground in a Thomas-Wiley mill to pass a 1mm screen . Samples were maintained in glass vials at room temperature following grinding until laboratory analysis could be performed.

4.2.4 Laboratory Analysis

All samples were dried in a vacuum oven at 65°C, overnight, prior to analysis. *In vitro* OMD of forage samples was determined by the procedures of Tilley and Terry (1963) as modified by Troelson (1970). Crude protein (CP) was represented by N x 6.25 as determined by the Kjeldahl procedure (AOAC no. 984.13, 1990). Fecal chromic oxide concentration was determined by the method of Kimura and Miller (1957) as modified by Holt (1992).Fecal organic matter output was estimated from the equation:

$$\text{FOM} = \text{fecal } [Cr_2O_3] \,/\, \text{daily } Cr_2O_3 \qquad \text{Equation 4.1}$$

Where FOM = fecal organic matter output

Fecal $[Cr_2O_3]$ = fecal chromic oxide concentration (mg kg^{-1})

Daily Cr_2O_3 = Cr_2O_3 provided by controlled release capsule=1.72 g day^{-1} Organic matter intake

(OMI) was calculated from the equation:

$$OMI = (FOM)/(1-OMD) \qquad \text{Equation 4.2}$$

Where OMI = organic matter intake

FOM = estimated fecal organic matter output

OMD = *in vitro* organic matter digestibility

Feed intake of animals in the drylot was calculated from the total amount of feed using the equation:

$$\text{feed intake} = \text{kg of feed provided} / (\#\ \text{of animals in pen} \times \text{days of trial}) \qquad \text{Equation 4.3}$$

Neutral detergent fibre (NDF) was determined by methodology derived by Van Soest et al. (1991). Acid detergent fibre (ADF) was established according to the AOAC Method No. 973.18 (1990). Total phosphorus content was determined following AOAC Method No.978.01 (1990).

4.2.5 Statistical Analysis

The initial experimental design represented a completely random design which included a factorial treatment design in the second year because of the supplementation. Data from each year were analysed separately using the General Linear Models Procedure for analysis of variance (SAS Institute, 1996). Significant differences ($P<0.05$) in treatment means were separated using the Least Significant Difference procedure (SAS Institute, 1996). Correlation coefficients were calculated for ADG in relation to changes in backfat for individual animals within treatments and for treatment means using Pearson's correlation.

4.3 Results

4.3.1 Animal Performance

Average daily gain and final backfat measurements were significantly different ($P<0.05$) between treatments within years (Tables 4.1 and 4.2). Animals in the GF treatment had the best performance followed by the FF treatment. Animals in WWG and BSG treatments only maintained weight and backfat in 1997.

In 1998, the GF animals had the highest gains (1.0 kg d^{-1}), but the BSG + S showed the second highest gains (0.8 kg d^{-1}). Animals grazing native mixed grass did show a favorable response to supplementation (0.2 kg d^{-1} without supplement; 0.4 kg d^{-1} with supplement) but the animal performance grazing western wheatgrass failed to show response to the supplement (Table 4.2).

Table 4.1. Initial weight, final weight, ADG, final ultrasound backfat depths and change in backfat for steers at SPARC from Oct. 27/97 to Jan. 7/98.

	GF[s]	FF[t]	WWG[u]	BSG[v]	SEM[w]
Initial Weight (kg)	223	225	222	226	9
Final Weight (kg)	289[a]	276[a]	229[b]	232[b]	9
ADG[x] (Kg d^{-1})	0.9[a]	0.70[b]	0.1[c]	0.1[c]	0.1
Final BF[y] (mm)	2.2[a]	2.1[a]	1.0[b]	0.8[b]	0.4
Δ[z] BF (mm)	1.5[a]	0.9[a]	-0.1[b]	-0.2[b]	0.5

Means within a row, followed by different letters, indicate significant difference as tested by LSD at $\alpha=0.05$
s=grain fed; t=forage fed; u=western wheatgrass; v=barley swath grazing; w=standard error of the mean; x=average daily gain; y=back fat; z=change in

The main effect of supplementation (Table 4.5) was significant ($P<0.05$). The addition of protein and energy to the BSG treatment resulted in increased intake and improved performance. In the NMG pasture, the provision of 1.0 kg of supplement per head reduced average forage intake by 0.7 kg, while increasing overall intake (Table 4.6) and improving animal performance (Table 4.2). On the WWG pasture, provision of supplemental protein reduced overall intake by 2.3 kg and forage intake by 3.3 kg (Table 4.6), while maintaining animal performance. Due to the differences in methodology for determination of intakes, it would be inappropriate to statistically compare the grazing intakes to the drylot intakes. Comparison among the grazing animal intakes revealed some significant differences ($P<0.05$).Forage intakes were highest for the SGB+S and lowest for the NMG, NMG+S and WWG+S. Calculated average feed:gain data are also presented in Table 4.6.

Table 4.2. Initial weight, final weight, ADG, final ultrasound backfat depths and change in backfat for steers at SPARC from Oct. 19/98 to Nov. 17/98.

	GF[o]	FF[p]	NMG[q]	NMG + S[r]	WWG[s]	WWG + S[t]	BSG[u]	BSG + S[v]	SEM[w]
Initial Weight (kg)	216	220	220	226	220	222	218	223	7
Final Weight (kg)	247	238	226	240	225	228	229	245	7
ADG[x] (Kg d^{-1})	1.0 [a]	0.6 [bc]	0.2 [ef]	0.5 [cd]	0.2 [f]	0.2 [ef]	0.4 [de]	0.8 [b]	0.1
Final BF[y] (mm)	2.0 [a]	1.3 [b]	1.2 [b]	1.2 [ab]	1.3 [b]	1.4 [ab]	1.4 [ab]	1.2 [b]	0.3
Δ[z] BF (mm)	-0.2	-0.6	-0.8	-0.2	-1	-0.6	-0.4	-0.7	0.3

Means within a row, followed by different letters, indicate significant difference as tested by LSD at α=0.05

o=grain fed; p=forage fed; q=native mixed grass pasture; r=native mixed grass pasture with supplementation; s=western wheatgrass pasture; t=western wheatgrass pasture with supplementation; u=barley swath grazing; v=barley swath grazing with supplementation; w=standard error of the mean; x=average daily gain; y= back fat; z=change in

Table 4.3. Estimated cost of gain ($ kg^{-1}) associated with backgrounding activity at SPARC in 1997 and 1998.

Year	GF[o]	FF[p]	NMG[q]	NMG + S[r]	WWG[s]	WWG + S[t]	BSG[u]	BSG + S[v]
1997	1.18	1.34	--	--	5.00	--	1.03	--
1998	0.99	1.47	2.50	1.24	2.50	3.10	1.50	0.90

o=grain fed; p=forage fed; q=native mixed grass pasture; r=native mixed grass pasture with supplementation; s=western wheatgrass pasture; t=western wheatgrass pasture with supplementation; u=barley swath grazing; v=barley swath grazing with supplementation

Table 4.4. Correlation coefficients and probabilities for average daily gain in relationship to the change in backfat for calves among all treatments in 1997 and 1998.

	1997	1998
r	-0.1	0.19
P	0.37	0.09

Table 4.5. Effect of barley and canola meal supplementation for grazing steers in 1998.

	Unsupplemented	Supplemented	Std Err
Initial Weight (kg)	219	223	18.7
Final Weight (kg)	226 [a]	237 [b]	19
ADG[y] (kg/d)	0.24[a]	0.47[b]	0.2

Means within a row, followed by different letters, indicate significant difference as tested by LSD at α=0.05
y=average daily gain

Table 4.6. Daily organic matter intakes on pasture as calculated from the use of chromic oxide boluses, drylot intakes from measurement of feed provided, and calculated Feed :Gain ratios for 1998.

	GF[1]	FF[1]	NMG[1]	NMG + S[u]	WWG[v]	WWG + S[w]	SGB[x]	SGB + S[y]	SEM[z]
Intake (kg d^{-1})	7.3	6.1	4.6[c]	4.9[c]	6.2[b]	4.9[c]	6.6[b]	9.7[a]	0.6
Forage Intake (kg d^{-1})	3.7	6.1	4.6[c]	3.9[c]	6.2[b]	3.9[c]	6.6[b]	8.7[a]	0.6
Feed : Gain	7.3	10.2	23	9.8	31	24.5	16.5	12.1	–

Means within a row, followed by different letters, indicate significant difference as tested by LSD at α=0.05
1.Intake established according to equation 4.1; r=grain fed; s=forage fed; t=native mixed grass pasture; u=native mixed grass pasture with supplementation; v=western wheatgrass pasture; w=western wheatgrass pasture with supplementation; x=swath grazing barley; y=swath grazing barley with supplementation; z=standard error of the mean

Table 4.7. Mean time spent grazing over a seven day period.

Treatments	NMG	NMG + S	WWG	WWG + S	SGB	SGB + S	Std Err
Mean (h d^{-1})	10.3^{c}	9.7^{c}	12.4^{a}	10.5^{bc}	10.6^{bc}	12.0^{ab}	1.33
Minimum (h d^{-1})	7.8	7	11.8	9	9	10	–
Maximum (h d^{-1})	12.5	10.8	13.5	11.3	12.3	13.8	–
Foraging Efficiency (kg h^{-1})	0.45	0.40	0.50	0.37	0.62	0.72	–

Means within a row, followed by different letters, indicate significant difference as tested by LSD at α=0.05

Average grazing time as recorded by a vibracorder is reported in Table 4.7. The provision of supplement significantly reduced grazing time of animals grazing a pasture of western wheatgrass with an associated decrease in feed intake (Table 4.7). No effect on grazing time or feed intake was apparent for supplemented animals grazing a native mixed grass pasture. The provision of the same supplement to animals swath grazing barley tended to increase the time spent grazing associated with increased intake.

Calves grazing SGB were more efficient in their grazing behaviour than calves grazing NMG or WWG. A portion of this advantage may be attributed to the concentration of forage in windrows in SGB in comparison to perennial grass pastures. Lower energy requirements for grazing activity as a result of greater intake per unit of time spent grazing (Table 4.7) and less energy expenditure walking in search of forage may have contributed to improved animal performance in BSG . Forage efficiency was weakly correlated to ADG ($r = 0.71$, $p = 0.11$, $n = 6$).

4.3.2 Feed Characteristics

Values of several characteristics which are used to evaluate forage quality are reported in Tables 4.8 and 4.9. Organic matter digestibility determined *in vitro* indicates a significantly lower value for the swathed barley in 1997 in compared to 1998. This is most likely a function of swathing the barley at a more appropriate physiological stage for greenfeed production in 1998. Crude protein concentration was lower than that required by growing calves for all grazed forages except swathed barley in 1998. Differences evident in OMD and CP of the hay in 1997 and 1998 can be explained by the type of hay provided. In 1997, alfalfa/smooth bromegrass hay was purchased while in 1998, smooth bromegrass/ alfalfa hay was made by SPARC staff for use in this trial.

In 1997, both BSG and WWG forage quality were inadequate based upon OMD and CP concentrations (Table 4.8). The poor ADG exhibited by animals within these treatments in 1997 (Table 4.1) appear to reflect the differences of the poor quality forage relative to the FF drylot treatment. In 1998 however, there was a range of forage quality among the pasture treatments. BSG had the highest OMD and CP concentrations with the lowest fibre concentrations while NMG exhibited the lowest OMD. Western wheatgrass was intermediate in OMD but lowest in CP concentration. Despite higher OMD in WWG compared to NMG, the ADG of the two treatments was identical.

Forage yields reported in Table 4.10 indicate the potential of annual crops to yield substantially more than perennial forages (1997) and the potential for significantly reduced annual yields by delaying seeding activities (1998).

Table 4.8. Quality characteristics of available forage for grazing animals in 1997 and 1998.

Treatment	Date	OMD[u] (g kg^{-1})	ADF[v] (g kg^{-1})	NDF[w] (g kg^{-1})	CP[x] (g kg^{-1})	TP[y] (g kg^{-1})
BSG	Sept/15/1997	449	402	658	75	1.3
WWG	Sept/15/1997	475	358	642	58	1.2
BSG	Oct/29/1998	754	223	414	123	2.6
BSG + S	Oct/29/1998	746	163	476	136	2.7
WWG	Oct/29/1998	670	382	687	51	0.7
WWG + S	Oct/29/1998	584	386	694	62	1.0
NMG	Oct/29/1998	471	404	696	69	1.1
NMG + S	Oct/29/1998	486	397	676	74	1.1

t = organic matter; u=organic matter digestibility; v=acid detergent fibre; w=neutral detergent fibre; x=crude protein; y = total phosphorus

Table 4.9. Quality characteristics of feed provided in drylot and pasture supplement.

	Date	OMD[u] (g kg^{-1})	ADF[v] (g kg^{-1})	NDF[w] (g kg^{-1})	CP[x] (g kg^{-1})	TP[y] (g kg^{-1})
Hay	1997	639	331	410	182	2.0
Hay	1998	479	367	548	137	2.0
Barley	1997 & 1998	796	94	235	113	3.7
Supp[z]	1998	520	127	205	257	7.1

t = organic matter; u=organic matter digestibility; v=acid detergent fibre; w=neutral detergent fibre; x=crude protein; y=total phosphorus; z=supplement

Table 4.10. Available Forage and Residual Forage yields and the resulting level of pasture utilization for backgrounding steers.

1997	SGB	SEM	WWG	SEM
Available (kg ha^{-1})	7954	156	2753	176
Residual (kg ha^{-1})	n/a		838	159
% Utilization			70	

1998	SGB	SEM	SGB + S	SEM	WWG	SEM	WWG + S	SEM	NMG	SEM	NMG + S	SEM
Available (kg ha^{-1})	1863	235	1560	143	1282	168	1769	168	1430	222	1320	127
Residual (kg ha^{-1})	380	190	691	238	498	126	407	155	286	150	253	128
% Utilization	80		56		61		77		65		81	

4.4 Discussion

This study indicated that backgrounding of beef calves swath grazing barley or grazing stockpiled mixed native forages can provide economically viable alternatives to drylot feeding of weaned calves. The use of barley swath grazing and native mixed grass pasture with supplementation produced gains at an approximately equivalent cost as in the drylot. The use of barley swath grazing with supplementation produced the lowest estimated cost of gain at $0.90 per kg.

Western wheatgrass was not found suitable for late season use by calves, even if supplemental protein and energy were provided, despite acceptable OMD in 1998. This is in contrast with the results of Jefferson et al., (1997) who reported calf gains of 1.1 kg day^{-1} when with dams on western wheatgrass. The provision of supplemental energy and protein in the current study, resulted in significantly reduced total intake compared to intake of western wheatgrass without supplementation. The substitution of supplement for forage indicates mature western wheatgrass is unpalatable to young beef calves. Higher intakes of WWG in comparison to NMG in 1998 (Table 4.6), of similar quality forages (Table 4.8) resulting in the same animal performance (Table 4.2) indicate a potential anti-nutritional factor may be present in western wheatgrass.

The use of a mixed native grass sward with supplement provided gains which are considered acceptable for backgrounding. Quality characteristics of the native mixed grass were similar to those of Lawrence (1977). Theses results suggest that maintenance of dry, bred, beef cows would be possible but gains on pasture alone for weaned animals would be highly unlikely. Forage intake and total intake of the native mixed grass sward in the current study

were unaltered by the addition of supplemental protein and energy. This is in agreement with the findings of Judkins et al. (1987) and Freeman et al. (1992). Del Curto et al.,(1990b) indicated that when forage crude protein is in the 70 g kg^{-1} range or lower, additional crude protein provided by the supplement probably improved rumen function, thereby improving energy and protein status of the animal, resulting in improved growth. This effect appears to have occurred in the native mixed grass with supplement treatment of the present experiment.

The major benefit of swath grazing annual cereal grains is yield potential. Yield variability of a spring seeded annual does create some management implications. Seeding took place at the end of May in 1997 and a yield of nearly 8000 kg ha^{-1} was realized. In order to reduce the time the crop would be exposed to weathering in the swath, seeding was delayed until mid June in 1998 (Klein, 1996; McCartney, 1998). Soil conditions were relatively dry, but the majority of the season's precipitation fell shortly after seeding. Crop development was poor as evidence by the reduced yield (1860 kg ha^{-1}). Reduced crop yield may have been the result of excessive tillage, to incorporate manure and residue, reducing available soil moisture. Crop development proceeded normally along areas where litter was present, corresponding to the location of windrows which had been swath grazed the previous winter. The area between the old windrow locations was extremely bare and exposed. In these areas, crop development was poor and resulted in reduced yield.

The 1997 crop had a very high fibre content (658 g kg^{-1} NDF; 410 g kg^{-1} ADF) and low digestibility (449 g kg^{-1} OMD). The poor forage quality exhibited by this crop was due to being swathed in the early milk stage rather than the recommended soft to mid dough stage. As a result, forming seeds shrunk into fibrous hulls, leaving forage of quality that was not much

better than would be expected from straw. The 1998 barley crop was swathed in mid August at the mid dough stage. This resulted in improved organic matter digestibility in 1998 compared to 1997. Additional precipitation was received following swathing and some regrowth occurred. This may have also attributed to the improved gains exhibited by the steers in 1998.

The gains made by the supplemented steers swath grazing barley were second only to the steers receiving barley in the drylot. Improved forage quality was a result of the combination of swathing at a more appropriate stage of crop development and barley regrowth. Forage intake and total intake were significantly increased with the provision of the supplement and is in agreement with the findings of Caton et al.,(1988). Considering the costs associated with swath grazing, weight gains need to be realized while swath grazing, not later during compensatory growth in the drylot. The economic estimates provided in Table 4.3 indicate that the economic variability of swath grazing appears to be less than that of perennial pastures but greater than in the drylot. The main factors influencing the cost of gain associated with barley swath grazing are dry matter production and the rate of animal gain which can be realized.

Organic matter digestibility of the supplement which was provided to the animals is reported as 520 g kg^{-1}. This seems highly unlikely considering canola meal is 850 g kg^{-1} digestible and barley is approximately 800 g kg^{-1} digestible (Ensminger et al., 1990). The most likely scenario is that some sample was lost from the test tubes because of gas production associated with the rapid initial rate of fermentation of such a highly digestible feedstuff, resulting in the reported value.

Backfat data from Vaage et al., (1998) indicate a positive correlation between backfat deposition and liveweight gain. The current study did not provide results with any detectable

significant differences. This is probably due to the small absolute value of the quantitative measurements with very little variability. One would expect the relationship of liveweight gain and backfat deposition to hold true. The short time period over which this trial was conducted may not have provided an adequate opportunity for this relationship to be evident.

4.5 Conclusion

Barley swath grazing in combination with an appropriate supplement does have a potential role in backgrounding activity in south western Saskatchewan. The use of barley swath grazing and/or native mixed grass containing appropriate forage species with a supplement, may contribute to the extension of the grazing season for weaned calves which are to be placed on grass as yearlings. The results of the current study suggest that western wheatgrass was unpalatable to young calves. The use of western wheatgrass for stockpiled grazing with or without protein and energy supplementation was not effective.

Chapter 5

General Conclusions

The development of strategies for the use of stockpiled forage for backgrounding activity allows producers to incorporate more flexibility into their operations. Planning to use pasture for backgrounding activity in the fall may allow additional gains to be made on calves prior to sale. In the event of drought, pasture backgrounding may be eliminated, providing additional pasture for the cow herd.

Selection of appropriate forage species and animal breed are factors to be considered prior to embarking on a strategy for the use of stockpiled grazing. The provision of wind shelter is extremely important in order to allow the animals some relief from environmental conditions.

The decision to provide a supplement is based on the economic impact provided. Reductions in the cost per kilogram of gain should be the objective of management decisions related to stockpiled grazing for backgrounding. Estimates of the cost of gain associated with these two trials indicate barley swath grazing and grazing native mixed grass with a supplement can be done at a comparable economic cost to drylotting of animals. The provision of a supplement to animals swath grazing barley produced the lowest cost of gain in 1998, trial 2 at \$0.90 kg^{-1}. The provision of Russian wild ryegrass pasture to weaned calves produced economically efficient gains at a cost of \$1.96 kg^{-1} in 1997 and \$0.91 kg^{-1} in 1998. The addition of appropriate supplement offers the opportunity to lower the cost of gain on Russian wild ryegrass pasture even further.

Western wheatgrass resulted in unacceptable animal performance even when supplemental protein and energy were provided. These results indicate that the palatability of western wheatgrass to young animals is unacceptable. Laboratory analyses indicate western wheatgrass should be of suitable quality to support some weight gains, but if animals refuse to ingest it, they cannot digest it.

Barley for swath grazing and Russian wild ryegrass provide forage which results in animal performance which is at the low end of acceptable weight gain for backgrounding animals. Native mixed grass pasture supplemented with protein and energy is also useful for production of animals intended for backgrounding on pasture the following summer. The gains realized by animals swath grazing barley and receiving supplemental protein and energy were similar to gains realized in the drylot. These result indicate very good possibilities for the use of Russian wild ryegrass, swath grazing and supplementation as management strategies for reducing the cost of gain during the backgrounding period.

Chapter 6

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Appendix A

Meteorological Data

Swift Current, SK

January 1, 1997 to January 31, 1999

Table A.1. Mean monthly precipitation, by type and total, and mean monthly snow depth at Swift Current from January 1997 to January 1999.

Year	Month	Rain (mm)	Snow (cm)	Precip (mm)	Snow Depth (cm)
1997	1	2	13.2	14.1	20.0
1997	2	0	1.4	1.5	23.9
1997	3	3	36.6	37.2	15.4
1997	4	40.3	0.8	41.8	0.0
1997	5	49.9	0	49.9	0.0
1997	6	69.8	0	69.8	0.0
1997	7	43.6	0	43.6	0.0
1997	8	48	0	48	0.0
1997	9	15	0	15	0.0
1997	10	16.1	6.2	20.9	0.0
1997	11	0	2.2	2.7	0.1
1997	12	0	1	0.2	0.1
1998	1	0	17.8	14.2	1.5
1998	2	3.6	2.4	6.2	0.1
1998	3	0.4	19.2	16.2	0.4
1998	4	11.8	3.4	15.9	0.0
1998	5	38.1	0	38.1	0.0
1998	6	90.1	0.4	90.5	0.0
1998	7	37	0	37	0.0
1998	8	35.3	0	35.3	0.0
1998	9	25.8	0	25.8	0.0
1998	10	33.2	6	41.7	0.1
1998	11	16	8.2	23.6	0.3
1998	12	0.2	32.8	25.5	1.8
1999	1	0	22	16.9	8.8

Table A. 2. Daily and monthly mean, maximum and minimum temperatures (° C), for January 1 to June 30, 1997.

	January		February		March		April		May		June	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	5.1	-18.2	1.2	-7	-6.4	-15.6	1	-2.9	7.7	-1.5	22.9	13.5
2	-0.8	-12.2	-1.4	-11	-8.8	-14.3	8.8	-4.8	11.2	-3	23.7	9.3
3	-1.6	-12.9	-4.8	-10.5	-14.6	-18.4	10.5	2.6	17.3	-1.9	22.9	5.9
4	-13.7	-17.2	-2.5	-9.8	-6.2	-23.6	-0.8	-3.4	16.4	5.9	29.8	12.4
5	-10.2	-19.8	-4.3	-10.9	-14.1	-20	-3.9	-7	16.3	1.3	29	15.6
6	-3.9	-16.7	-4.5	-12.6	-6.3	-20.4	-4.7	-13.8	21	4.8	26	15.9
7	-3.2	-10	-4.6	-9.7	3.4	-12.6	-8.9	-15.7	10.8	3.4	24.1	13.3
8	-4.5	-9	-7.2	-14.7	-0.9	-8.1	-5.3	-15.6	17.1	-2.5	19.8	14.2
9	-29.1	-30.4	-5.3	-11.7	1.1	-8.9	-2.7	-13.7	22.8	5	16.9	13.5
10	-32.1	-36.9	-5.8	-9.6	-2.1	-6.1	-0.1	-11.7	14.4	5.7	15.2	10.8
11	-28.3	-36.5	-9.2	-12.1	-4	-6.1	5.3	-9.2	15	-1.6	21.3	12.6
12	-18.7	-33.2	-3.1	-18.6	-14	-15.4	9.3	-7.5	25.8	1.4	24.8	12.7
13	-14.1	-23.2	-4.5	-9.7	-13.9	-17.3	14.8	-3.1	14.9	4.9	23.8	14.1
14	-4.1	-18.4	-1.7	-15.7	-13	-25.1	6.5	0.8	17.4	-2	22.6	13.4
15	-14	-21.2	2.8	-12.5	-6.8	-24.8	12.5	-7.3	26.9	5.6	24.7	9.4
16	-20.6	-30.7	5.5	-8.9	-5.3	-13.1	22.2	0.7	25.8	8.9	23.9	14.9
17	-1.5	-27	6.5	1.8	-7.9	-19.8	18.9	5.8	18.4	12	24.7	7.8
18	0.8	-13.6	-2.4	-12.5	5	-10.5	16.4	0	4.4	-0.9	23.9	14.9
19	0.8	-6.3	3.1	-7.3	7	2.2	14.9	5.2	10.4	1.5	18	9
20	-1.3	-7.6	-0.9	-6	8.1	3	18	-1.2	14.4	-0.9	19.5	6.6
21	-10.4	-16.7	0	-8.9	3.8	-2.5	6.4	5.1	13.6	3.1	18.4	10.2
22	-13.8	-21.2	-9.9	-15.1	6.3	-4.1	7	3.1	9.5	3.3	20.9	7
23	-14.4	-19.6	-5.7	-16.9	5.4	-1.8	9.5	0.4	7.4	4.7	20.9	8.8
24	-28.1	-28.8	5.9	-13.3	2.9	-1.4	11.1	-1.6	11.6	6.4	17.9	8.7
25	-28	-36.2	1	-1.5	13.2	-2.9	13.4	1.9	12.9	5.9	22.7	8.1
26	-24.8	-35.4	-6.3	-15.3	11.6	1.4	12.7	0.7	17	6.3	29.7	11.4
27	-20.8	-33.6	-6.4	-14.2	7.3	0.4	19.1	3.6	18.2	5.7	23.6	8.6
28	-16.3	-26.8	-6.5	-14	6.8	-1.8	13.3	1.9	18.4	8.7	23.1	7.7
29	2.8	-27			9.6	-2.6	10.9	-5.3	21.4	7.7	13.7	7.7
30	5.7	-4.8			12.4	-0.4	14	1.5	25.1	9.2	10.1	7.8
31	2.2	-1.4			13	1.3			26.8	13		
Mean	-11.0	-21.0	-2.5	-11.0	-0.2	-9.3	8.3	-3.0	16.5	3.9	22.0	10.9

Table A. 3. Daily and monthly mean, maximum and minimum temperatures (° C), for July1 to December 31, 1997.

	July		August		September		October		November		December	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	12	7.1	31	12	19.2	0.5	23.2	13.7	9	-0.9	2.9	-7.2
2	17.6	5.6	28.4	14.1	29.7	9.2	25.8	14.4	7.8	-0.9	2.3	-11.1
3	21.6	6.6	30.2	11.5	27.9	16	16.1	7.5	11.1	-3.2	-0.5	-7.4
4	22.1	10.9	33.8	15.7	26.6	16	19.9	2.9	7.6	0.4	-8.6	-18.3
5	22.5	6.6	31.6	14.6	20.6	10.3	13.4	4.8	11.6	-2	-4.2	-16.9
6	26.9	11.8	35	16.2	26	9.7	16.1	-2.5	17.9	3.1	-4.4	-14
7	22.9	11	35.5	17.6	21.8	6.1	11.1	5.3	4.5	1.3	-9.7	-17.3
8	25.3	12.1	16.7	13.3	21.3	5.9	2	0	1.4	-9.1	-8.9	-11.4
9	27.1	16.4	13.9	7.1	26.5	8.4	4.7	-0.6	0.1	-11.3	-7	-12.4
10	26.8	12.8	20.1	4.6	28.1	8.5	15.6	1.6	-3.7	-12.8	-4.2	-13.1
11	22.5	11.7	23.2	8.5	31.1	14.5	5.9	2.7	-1.7	-13.9	3.2	-9.4
12	23.3	7.7	23.6	6.1	18.3	13.1	2.9	-0.3	0.1	-6.6	5	-3.6
13	25.4	9.4	29.9	12.5	17.7	7.1	6	-7.8	-4.3	-7.6	10.9	0
14	27.6	11.3	25.3	12.4	16.7	6.1	14.4	-3.6	-2.4	-16.5	14.2	1.4
15	28.3	12.5	13.3	11	18	7.9	16.7	0.1	3	-12.1	4.4	1.2
16	27.5	12	16.9	7.7	11.8	6.1	23	6	-2.1	-11.5	10.4	-5.6
17	25.9	11.5	20.5	7.8	18	2.2	21.6	6.4	-8.6	-10.2	8.2	2.7
18	25.3	13.9	20.9	9.6	7.7	2.5	9.3	3.4	-2	-10.6	-2.4	-8.1
19	25.7	8.8	23	8.5	12.2	-1.8	9.3	-5.1	-2.7	-6.1	-1.8	-13.4
20	26.5	12.9	26.1	11.3	21.5	2.2	3.9	-8.7	-6	-6.8	3.3	-6.3
21	27.9	12	24.8	10.1	24.9	5.8	11.8	-3.7	-4.1	-13.4	1.6	-2.4
22	32.8	15.2	28.4	14.3	25.1	7.5	10.8	-3.8	0.5	-13	-0.1	-11
23	26.9	10.9	31.8	12.3	28.8	11	-0.6	-2	6.9	-11.7	1.2	-6.9
24	27.5	9.9	26.1	14.1	28.6	8.5	-3.7	-5.9	9.5	-3.6	0	-8.1
25	22.4	11.9	25.7	10.3	30.2	10.2	0.4	-9.9	4.6	-4.3	4.4	-7.3
26	19.3	7.8	29.6	12.1	29.7	10.5	9.6	-1.6	3.1	-5.6	4.8	-7.7
27	24.1	8.6	32.8	15.1	20.2	8.2	8.3	4.3	4.4	-10.1	1.3	-2.5
28	25.8	13.3	27.2	12.7	19.8	7.8	5.7	-3.3	9	-0.7	3.8	-8.6
29	28.4	13.4	24.7	12.6	20.6	5.6	10.1	-2.2	5.8	-3.1	6	-5.7
30	30.5	12.9	23.3	7.9	28.7	5.8	11	0.4	8.5	-3.3	0.9	-8.4
31	28.4	15.8	27	10.3			9.8	-1.2			9.5	-8.4
Mean	25.1	11.1	25.8	11.4	22.6	7.7	10.7	0.4	3.0	-6.9	1.5	-8.0

Table A. 4. Daily and monthly mean, maximum and minimum temperatures (° C), for January 1 to June 30, 1998.

	January		February		March		April		May		June	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	-5.6	-10.7	-5.9	-8.8	-4.4	-13.1	16.1	-0.6	14.1	-5.9	16.5	11.1
2	-20.6	-22.6	-2.4	-8.8	-0.2	-9.6	14.3	-1.2	22.3	1.3	10.7	-0.2
3	-18.1	-32.2	2.8	-5.4	-2.9	-14.8	17.5	-0.1	27.4	8	15	-0.5
4	-14.7	-24.4	-1.2	-7.5	-4.8	-11.6	17.1	3.8	18.1	4.5	13.4	4
5	-4.4	-19	-0.4	-4.5	-3.9	-11.6	9.8	1.1	22.9	4.3	14.1	0.7
6	-13.5	-18.9	-5.5	-8.5	-4.2	-9.2	8.2	-0.8	12.1	1.5	16.5	4.5
7	-18.5	-19.5	3.1	-7.9	-6.8	-14.4	9.3	-0.3	17	-2.4	16.5	2
8	-24.7	-25.7	-6.5	-7.4	-13.8	-20.7	10.7	-2	18.9	-0.7	17.2	6.5
9	-27.6	-29.9	-2	-9.7	-12.4	-22.2	9.9	-0.5	18	3.7	20.6	7.6
10	-30.2	-35.4	2.6	7.4	-11.3	-22.3	13.3	-2.2	15.8	4.5	25.4	10.6
11	-30.5	-34	1.3	-4	-2.2	-19.9	17.2	0.7	18.4	2.3	25.4	7.8
12	-21.3	-35.1	4.3	-7.3	11.7	-7.7	12.7	2.5	17.4	2.1	21.4	10.3
13	-13.5	-29.9	7.8	-2.3	-3.9	-10.2	8.3	-2.2	19	-2	21.6	8.9
14	0.8	-25.1	6.1	-2.8	-4.9	-11	4.9	-1.8	19.1	4.7	19.9	7.5
15	-1	-14.7	7.1	-4.3	6.6	-11.1	7.9	-7.1	16.8	6.1	20.8	8.5
16	-14.2	-19.4	1	-5.8	8.3	-4.5	8.7	-2	19.4	3.9	21.1	11.1
17	-10.9	-19.1	3.4	-3.9	-2.8	-4.8	12	-4	19.4	4.3	20	8.5
18	-7	-20.9	2.2	-3.1	-4.6	-7.2	6.9	-4.3	10.8	8	18.7	6.5
19	-7.2	-13.1	8.5	-3.8	0.8	-6.1	12.6	-6.7	19.8	4	12.6	8.9
20	-10.2	-12.1	10.1	-1.3	5.2	-9	17.2	-0.2	24.5	6.6	12.8	9.5
21	-9	-13.5	8.8	-0.7	2.4	-6.6	21.5	0.3	23.5	11.6	17.5	10.5
22	-9.8	-15.8	7.7	0.6	-0.2	-3.4	22.2	4.9	22.7	11.6	25.2	8.2
23	-1	-18.8	5.1	-1.9	1.5	-5.8	24.1	7.4	22.6	9	23.2	13.4
24	2.3	-7.9	4.5	-6.2	11.2	-1.8	21.6	8.7	24.2	8.8	26.6	13.4
25	-4.3	-10.8	3.2	-4.1	13.8	0.7	7	2.1	24.8	9.9	25.9	11.7
26	5	-11.2	-4.2	-8.5	13.2	0.4	10.8	0.9	25.8	10.8	24.9	14.2
27	1.1	-5.4	-5	-11.6	8.4	-1.2	21	2.2	24.1	12.4	16.5	12.4
28	1.3	-9.1	-5.7	-10.6	6.3	-6.1	24.1	5.4	18.1	6.9	18.9	8.7
29	4.6	-5.3			7.4	-5.9	26.6	7.8	21.4	3.3	21.9	13.8
30	2.8	-1.4			11.8	-2.3	18.2	5.5	20.5	8.1	24.9	13.4
31	2.6	-5.4			15.4	-1.9			26.5	3.1		
Mean	-9.6	-18.3	1.8	-5.1	1.3	-8.9	14.4	0.6	20.2	5.0	19.5	8.5

Table A. 5. Daily maximum and minimum temperatures (° C) for July1,1998 to January 1,1999.

	July		August		September		October		November		December		January	
Date	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
1	26.6	12.8	28.9	14.3	29.3	6.8	16.1	2.3	8.8	0	7.8	-5.7	-18.7	-22.7
2	22.1	14.3	25.9	15.5	32.8	15.4	13.4	4.5	4.5	3.3	8.4	-5.2	-19.5	-23.3
3	20.2	13.8	26.1	15.8	28.4	13.2	10.2	6.1	2.4	0.5	-2.8	-6.7	-11.8	-24.7
4	25.5	15.4	29.7	12.7	28.2	15.9	12.2	3.3	2.5	-1.2	-3.5	-5	-4.3	-26.4
5	24.6	13.5	32.5	16.7	24.9	6.6	7.9	2	0.2	-1.1	-4.5	-6.7	-0.5	-14.8
6	23.5	11.4	35.9	18.8	25.8	7.4	16.1	-0.4	-5.2	-7.3	-5.4	-15	-21.1	-28.3
7	26.5	14.5	32.5	13.8	31.3	13.6	22.5	5	-2.9	-6.2	-1.5	-10.5	-19	-30.4
8	27.9	16	27.7	13.8	32.4	18.9	21.6	8.8	-3.6	-5.1	0.4	-7.7	-11.3	-31.2
9	29.5	15.8	33.1	14.9	32.2	11.4	16.5	2.2	-3.4	-4.7	0.4	-7.9	-12.3	-25.4
10	31.7	17.9	34.9	17.1	20	12.1	5	-0.2	-1.1	-7.3	5.6	-6.5	-12.7	-23.7
11	29.6	17.3	33.3	14.2	26.7	6.6	-0.5	-1.9	-6.7	-8.5	3.8	-2.1	-18.2	-20.8
12	25.8	14.8	32.9	.14	25.8	9.8	-0.3	-3.2	5.4	-13.6	5.1	-3.9	-7.2	-27.5
13	27.1	14.2	28.2	14.9	28.6	11.5	8.8	-2.8	10.4	-1.1	11	-0.8	-2.5	-19.5
14	24.3	11.9	26.9	9.8	24.2	4.4	10.9	1.6	3.5	-5.5	6.8	-0.6	4.7	-8.2
15	21.6	7.4	31.3	15.9	26.8	12.5	12.5	0.5	-5.2	-9.2	2.9	-9.6	0.7	-1.6
16	26.7	13.6	22.3	9.6	28.8	10	2.3	-0.4	-6.2	-9.7	6.5	-5.3	-1.5	-10.2
17	33	16	26.1	13.2	24.4	6.4	10.6	-1	-7.7	-15.7	6.3	-3.9	-5.8	-11
18	30.1	14.2	26.4	12	18.4	8.3	7.1	0.7	-2.7	-10	-17	-20.7	-3.8	-13.3
19	31.5	11	24.7	8.9	10.4	7.6	10.7	-2.7	2.6	-5.3	-21.2	-23	-7.3	-9
20	25.1	13.3	27.4	9.8	11.5	2.4	15.4	-1.7	4.6	-9.2	-24.1	-29.4	-0.8	-11.4
21	22.3	9.5	27.8	15	16	1.2	20.6	1.9	9.5	1.6	-14.2	-31.8	-11.6	-14.3
22	21.8	8	27.5	14.8	20.4	5.5	21.3	5.7	5.8	0.8	-15.2	-25.5	-8	-16.7
23	25.5	7.3	25.6	11.3	19.9	8.7	15.9	-0.3	6.2	-2	-18	-23.2	-14.6	-18.1
24	32.1	13	24.8	11.4	13.4	8.3	16.9	-1.1	8.7	0.4	-14	-22	-7.5	-27.6
25	34.2	17.6	27.6	10.6	10.7	4.7	17.5	0.6	8.5	0.6	-12.4	-24.5	-5.4	-20
26	28.6	12.9	29.4	10.2	11.2	5	15.4	3.9	13.8	3.9	-7.4	-23	-4.6	-14.6
27	31.3	16.3	28.4	8.8	21.4	4.4	17.2	1	7.1	0.2	-12.2	-16.3	-5.7	-11.7
28	26.4	13.8	26.8	10.7	17.4	5.8	11.1	7.8	5.7	-0.8	-17.5	-19.4	-0.7	-12.4
29	23.9	10.8	32.1	12.1	12.5	7.1	8.1	1.2	0.2	-5.2	-15.2	-26.7	3.1	-9.5
30	28.5	9	32.9	14.9	13	-2.2	5.4	-2.7	1.7	-4.8	-17.3	-18.8	3.3	-0.2
31	29.9	14.4	22.5	10.6			5.5	-4.3			-9.5	-18.7	0.7	-7.3
Mean	27.0	13.3	28.8	13.1	22.2	8.3	12.1	1.2	2.2	-4.1	-5.4	-13.7	-7.2	-17.3

A Risk Efficiency Analysis of Backgrounding and Finishing Calves on Pasture in Saskatchewan

A Thesis

Submitted to the Faculty of Graduate Studies and Research

In Partial Fulfillment of the Requirements

For the Degree of Master of Science

In the

Department of Agricultural Economics

University of Saskatchewan

Saskatoon, Saskatchewan

By Brian Joseph Perillat

July, 2001

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Abstract

Perillat, B.J., M.Sc., University of Saskatchewan, Saskatoon, Saskatchewan, July, 2001. A Risk Efficiency Analysis of Backgrounding and Finishing Calves on Pasture in Saskatchewan. Supervisor: W.J. Brown.

Intensive cattle feeding typically takes place in confined areas. Backgrounding and finishing cattle in a pasture environment is becoming more common. This thesis examines the risk efficiency of several backgrounding and finishing options that include various grazing systems compared to the traditional drylot for three soil-climatic environments in Saskatchewan.

The probability distribution of economic profit was generated for each trial by combining a distribution of production and price possibilities. Feeding cattle on pasture is more dependent on weather conditions than traditional drylot systems, and weather variability was an important part of the analysis undertaken. Historical weather data were used along with GrassGro, a simulation model of forage and cattle production, to generate a distribution of production and profit outcomes for each trial. The budgets and prices were based on the year 2000's costs and prices. To add price variability to the model, historical price margin changes between the buying and selling weights of cattle were calculated, and the year 2000 prices were varied by these margins.

The risk analysis was completed using the Mean-Standard Deviation (MSD) framework, and stochastic dominance principles. The stochastic dominance analysis used the RISKROOT program.

Results of the study showed that feeding systems, which included grazing, were economically competitive with traditional drylot feeding systems. Finishing cattle on pasture with the addition of supplement was an attractive option, especially in areas

where high pasture productivity can be achieved. In all locations, more intense systems that included pasture fertilization and energy supplement, increased production and risk efficiency. In Swift Current, where rainfall and pasture productivity are traditionally lower, drylot backgrounding may still be the most risk efficient feeding system, depending on the decision maker's level of risk aversion.

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This study, and my schooling experience has been extremely enjoyable and rewarding because of faculty, staff, and fellow students in the Agricultural Economics Department. I am very grateful for meeting, working with, and developing friendships with so many people in the department. The general knowledge gained, and experiences shared over the last few years will never be forgotten.

Most importantly, I must thank my family. My Mom, for convincing me to go to university, helping me make a decision that could possibly have the biggest impact on my life ever, my Brother for guiding me into the agriculture college, and leading me towards agricultural economics. Finally Dad, who's patience allowed me to go to university and enjoy these experiences while helping me develop my farm and academic dreams beyond anything I ever imagined. Mom and Dad, thanks for looking after my cattle so well, for so long.

The university years have definitely been an eye opening experience, but possibly the most critical discovery I have made is:

"The more I learn, the more I realize how little I know"

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Chapter 1 Introduction

1.1 Background

Per Capita beef consumption in Canada has dropped over the last 20 years, while pork has remained relatively constant, and chicken consumption has increased significantly. The pork and poultry industries have undergone significant change to improve efficiency and deliver consistently high quality products to consumers. These two industries have built a highly coordinated supply system to transfer information, and have a production system that is very structured and consistent between producers. This helps in monitoring, and making improvements or changes in specific areas. Having producers more specialized at different levels of the beef supply chain could help improve the overall efficiency of beef production, either through more consistent products or reducing costs of production, which will allow beef to be more competitive with other red meats at the retail level. Therefore, any new production methods which are more efficient, will improve the competitiveness of the Canadian beef industry.

The cattle industry in Canada has been restructuring and consolidating, especially at the feedlot and processing level. This consolidation has created further incentives for specialized feedlots. Specialization by feedlots has led to the development of another stage of production referred to as backgrounding. Backgrounding normally involves taking newly weaned calves, and feeding them a grower ration to prepare them for a finishing ration at the feedlot. A grower ration is fed to animals to increase frame size while not adding much fat. The finishing ration is a high energy ration fed to

increase fat and muscle, to prepare animals for slaughter. Finishing rations are a high energy ration consisting of mostly grain while a backgrounding ration can have a higher proportion of forage. Currently in Western Canada, the large feedlots and high capacity slaughter plants have been developed in Alberta. Backgrounding operations are still developing, and this could give Saskatchewan producers an opportunity to become a more important player in the Canadian beef industry.

1.1.1 The Cattle Feeding Industry

Cattle feeding operations are faced with a margin squeeze between feeder cattle prices and feed costs. Once producers have estimated a sale price, and are fairly certain of feed costs for the feeding period, they can calculate a break-even price to pay for weanling calves. Competition in the feeding industry means this break-even price is fairly similar for most producers and the price of feeder calves is bid close to this price. One way for producers to become more competitive and more profitable is to find a more efficient or cost effective method of feeding the animals.

Backgrounding, and especially finishing, traditionally occurs in drylots where animals are fed processed feed in a confined area. An alternative method is to use a grazing system wherein animals to be backgrounded are fed grower rations through the winter and then placed on pasture in spring to graze through the summer, and then put on a high energy finishing ration in a drylot in fall until finished. One of the cheapest methods of feeding is when animals gather their own feed, therefore, methods which extend the grazing season can result in improved profitability (Adams et al., 1994). Expensive and mechanized machinery is required to gather and deliver feed to cattle confined to a drylot. Having cattle gather their own feed reduces costs significantly, but

this system may not be the most efficient method because there may be forage production limitations due to unfavorable weather. Within the backgrounding system, grazing could be a more feasible option because animals are mainly required to grow, rather than fatten. There are several options for backgrounding, such as, strictly drylot feeding, strictly grazing in the summer, or combinations of grazing and supplemental feeding. There has also been some consideration of trying to graze late into the fall, with or without, supplemental feeding. To finish cattle on pasture, they are typically put on pasture at a heavier weight during the peak growing period of the forage and are fed supplements.

It is important to consider all costs, including opportunity costs, when comparing alternative methods of producing beef. Grazing systems have low variable costs, but the total cost including the cost of land and pasture development can be quite substantial. Fixed and variable costs have to be thoroughly analyzed and compared for each feeding system.

One concern when there is a heavy reliance on grazing, is the effects of weather conditions. Weather conditions are the main factor determining the overall efficiency of the feeding system. If it is a dry year and the crop is poor, cattle will not perform and may require supplemental feed, which could be very expensive, especially if unanticipated. If it is a dry year, and feed needs to be purchased for cattle on pasture, there is generally a shortage of feed in the area and feed can become very expensive. Also, within any production system, it may be necessary to alter the feeding regime. For example, it may only be efficient to graze in the summer, or to graze and supplement only as long as the cattle can forage for themselves. It may also be the case that once a facility is in place for drylot feeding, it may be best to run it at full capacity year round

to reduce fixed costs per unit produced, and to take advantage of controlled feeding for optimal gains.

1.2 Problem Statement

Backgrounding beef calves may create opportunities for Saskatchewan cattle producers, but with highly competitive markets and thin profit margins, it is difficult for producers to establish themselves and choose the most economical feeding system. There are many feeding systems, each with different levels of potential productivity gains and economic returns and risk. Finding the most profitable system with an appropriate level of risk is the problem most producers face.

Grazing systems have been used in the past for feeding calves and yearlings. In many cases, operators would only graze calves at certain times, or in certain years, if the conditions are favorable, or if it is the best alternative in the short-run. Further research is required to compare the long-run profitability and riskiness of using alternative grazing systems for intensive backgrounding and finishing operations under Saskatchewan conditions.

1.3 Hypothesis

The hypothesis of the study was that a cattle feeding system, which includes grazing, is more profitable and risk efficient than the traditional drylot feeding system under Saskatchewan soil-climatic conditions.

1.4 Objectives

The objective of this research was to determine and compare alternative feeding systems for backgrounding beef calves in Saskatchewan, and to identify the most risk efficient method of feeding light weight cattle to prepare them for finishing in feedlots. In addition, the analysis compared the risk efficiency of finishing calves on pasture with

supplement to the traditional drylot management. The thesis incorporated the effects of weather on production, and compared the returns from various backgrounding options at different periods of the year.

Backgrounding is more common on lighter, smaller framed, usually British-cross, calves. Larger framed cattle are backgrounded less, because if backgrounded, they finish above the optimal size. These large calves also need less time to adapt to high performance finishing rations, and therefore, usually go straight into the feedlot. It has also been shown that backgrounding larger framed animals is less profitable than smaller framed animals (McNinch, 1995). Thus, this study will focus on using grazing systems for backgrounding and finishing smaller framed animals.

1.5 Outline of Thesis

Chapter two provides background information about the Western Canadian beef industry in general, and in Saskatchewan. The different stages of production are discussed including some historical statistics of cattle numbers in Saskatchewan. The beef industry has been an important part of Saskatchewan agriculture, but the backgrounding industry is still in the developing stage and has not undergone the concentration and centralization as has the feedlot and processing activities. Chapter 2 discusses the future possibilities of backgrounding in Saskatchewan, with emphasis on pasture management and different grazing systems.

The theoretical framework of the thesis is presented in chapter 3. It is based on risk and uncertainty analysis. A discussion of risk is included, along with the concept of the risk efficient frontier, and risk/return trade-off for different investments. Finally, stochastic dominance analysis is described as a method for choosing among risky alternatives.

Chapter four outlines the methodology of the thesis and the empirical model. The model is based on representative operations for the main soil-climatic zones of the Province, comparing the returns of different feeding systems, using different feeding periods, and historical weather data. The different production systems analyzed included the traditional drylot system, summer grazing using a complementary grazing system, employing Crested Wheatgrass (Agropyron cristatum) (CWG) for early season grazing, and continued grazing of Russian Wild Ryegrass (Psathyrostachys junea) (RWR) grass for late season grazing. In addition, each grazing system was examined with and without the provision of supplemental feed. These different systems were studied for three locations in Saskatchewan. It was assumed that calves were purchased at the beginning of each period and sold at the end. Production numbers were estimated using the GrassGro model, and a description of the model was included in this chapter. These production numbers were used in the profitability analysis comparisons for the different alternatives provided in Chapter 5. An Excel spreadsheet was developed to complete the profitability comparison. This spreadsheet program was used to generate distributions of net returns, and the RISKROOT program was used to estimate which alternatives were risk efficient.

The final chapter, chapter six, outlines the conclusions based on the findings, and comments on the limitations of the study and areas where further research could be beneficial.

Chapter 2 Industry Background

2.1 Introduction

This chapter focuses on the Western Canadian beef industry and beef production in Saskatchewan. Comparisons are made between other areas of Canada and other sectors, to illustrate how the beef sector is an important part of the agriculture industry. The chapter begins with a general discussion about the beef industry, along with a discussion about industry growth, and the cattle cycle. The following section summarizes the feeding stages in the beef industry. Finally, a discussion is provided about pasture and pasture management, and a description of the pasture grasses used in this study.

2.2 The Beef Industry

The beef industry in Canada, and Saskatchewan, has always been an important part of agriculture, but in recent years, it has been one of only a few positive sectors in prairie agriculture.

Toward the end of the 1990's, the portion of farm receipts from cattle has been increasing, mainly because of the increased prices of feeder and finished cattle, and decreasing prices for cereal grains. The price of calves in the year 2000 was at a record high. Saskatchewan is home to commercial cow/calf producers, purebred breeding stock producers, and a variety of backgrounding and finishing feedlots. Farm cash receipts

generated from cattle, and total farm receipts for Saskatchewan are presented in table 2.1. Saskatchewan is an extremely crop oriented province, with the majority of farm receipts coming from grain sales. Cattle and calves sales generate 11 to 17% of total farm receipts in Saskatchewan. The high amount of grain sales in Saskatchewan makes the cattle receipts as a percentage of total farm receipts lower in Saskatchewan compared to other provinces. Alberta has 30 to 40% of its receipts from cattle and calves, which is significantly higher than Saskatchewan.

Table 2.1 Cattle and Calves Receipts and Total Farm Receipts for Saskatchewan

	Cattle and Calves Receipts	Total Farm Cash	% Cattle Receipts of Total Receipts
Year	(Thousand dollars)	(Thousand dollars)	
1990	588,944	4,030,819	14.6%
1991	561,076	4,129,842	13.6%
1992	644,273	4,393,210	14.7%
1993	763,835	4,548,430	16.8%
1994	682,868	5,059,837	13.5%
1995	625,260	5,396,959	11.6%
1996	622,476	5,778,503	10.8%
1997	807,997	6,036,700	13.4%
1998	858,415	5,618,804	15.3%

Source: Sask. Ag. and Food

Saskatchewan has many characteristics that give it a comparative advantage in feeding cattle. Hot summers, and cold winters, ensures that Saskatchewan's feeder cattle and seedstock are both hardy and adaptable. A rigid health testing system contributes to a health status that is first-rate around the world. Forage and cereal grain production are relatively low cost, with limited competing uses for the feed and feed producing resources. Most other crops that are grown on this land have low economic returns. Feed costs are relatively low because of the long distance to market, which decreases the farm gate price for feed grains. There is also a lot of open space, allowing feedlots to

locate in areas where most feed and bedding can be produced nearby and where the manure can be spread on the surrounding land. There is also ample, high quality water available in most locations, and the areas have a relatively low human population density (Saskatchewan Agriculture and Food, 2001).

Even with a comparative advantage in many of the resources needed for cattle production, the beef industry in Saskatchewan has not developed as rapidly as expected, especially given the poor returns to traditional crop production. On the other hand, Alberta is beginning to experience some growth and development problems in their feeding industry. There are problems of congestion of feedlots in areas, concerns with impacts on water quality, odors, and manure disposal, and feed prices have tended to climb in Alberta, yet Alberta has seen tremendous growth in their feeding industry (Figures 2.1 and 2.2). Alberta has two major slaughtering plants, and has been able to establish a strong finishing sector around them.

In comparison to Alberta, Saskatchewan's cow numbers have followed a similar pattern (Figure 2.1), but steer numbers have increased significantly in Alberta and have declined in Saskatchewan (Figure, 2.2). This suggests that feeder calves are most likely moving out of Saskatchewan and into Alberta. Table 2.2 shows that in 1999, most of the feeder cattle in Saskatchewan moved into Alberta, where as in 1995, more calves were fed in Saskatchewan compared to any other area.

Table 2.2 Destination of Saskatchewan Feeder Cattle Marketed

Destination	1995	1996	1997	1998	1999
Saskatchewan	371,880	343,090	365,390	321,170	370,350
Alberta	352,420	370,290	472,640	471,960	575,660
Other	131,340	183,440	173,490	135,000	156,930
Total	855,640	896,820	1,011,520	928,130	1,102,940

Source: SAF Agricultural Statistics 1999

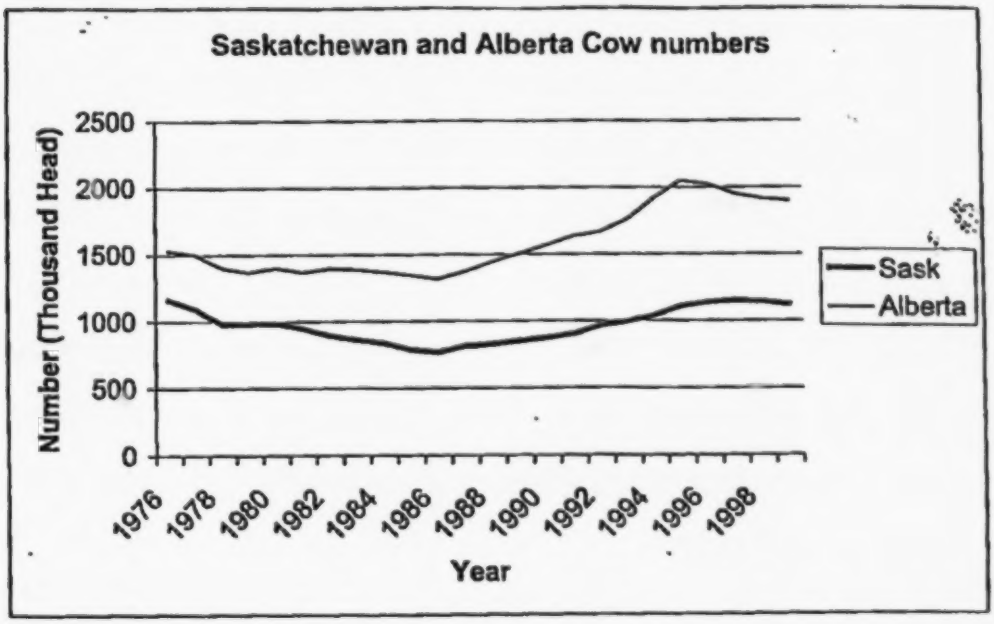

Figure 2. 1 Saskatchewan and Alberta Cow Numbers

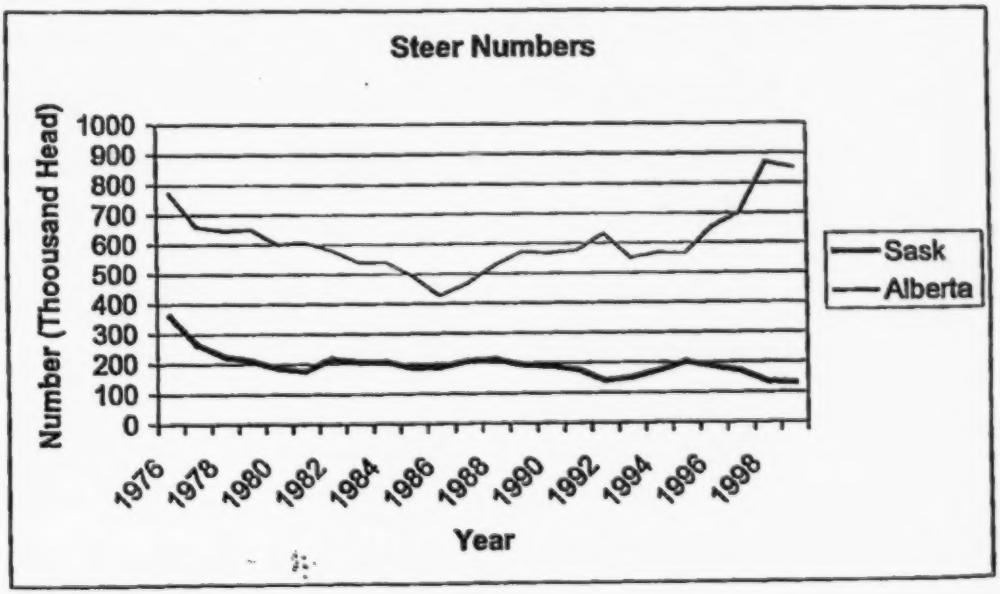

Figure 2. 2 Saskatchewan and Alberta Steer Numbers

Source Canfax 2000

2.2.1 The Cattle Cycle

A very dominant issue when studying cattle populations and prices is the cattle cycle. The cattle cycle occurs because of the biological lag associated with beef production (Coghill, 1997). Cow-calf production cannot respond immediately to price fluctuations because of the long gestation period (286 days) and reproduction cycle in cattle, and long feeding and finishing process (14 to 18 months) for animals. This creates a consistent oversupply or undersupply of calves. Production is continually trying to catch up to the market price signals, and a cyclical pattern of prices and production occurs.

At the bottom of the cattle price cycle, there is an oversupply of beef. Individual producers respond to these low prices by culling more cows and retaining fewer heifers as replacements. This reduction in cow herd size begins the contraction phase of the cattle cycle. The cow herd becomes smaller, resulting in fewer calves and subsequently a lower beef supply. Market prices increase as buyers compete more aggressively to purchase calves from a smaller population. Producers respond to higher prices by retaining more cows and replacement heifers. This increases prices further, in the short-term, as even fewer cattle are sent to market. Eventually, retaining more females will result in a larger cow herd, and the beginning of the expansion phase of the cycle. As herds expand, more calves are made available, so buyers need not bid as aggressively, and prices begin to fall. Responding to lower prices, producers cull more cows, starting the next contraction phase, and the cycle begins again (Canadian Beef Export Federation, 2001). Cattle cycles typically last 8 to 11 years. Calf prices have reached relative highs in 1931, 1943, 1951, 1958, 1962, 1973, 1979, 1987, and 1993. If price

peaks are compared to production peaks, there is generally a two or three year lag of production peaks behind price peaks (Carlberg, 1999).

2.3 Beef Production

There are five major stages in the beef supply chain, three feeding stages, slaughtering and processing, and retailing. First, is the cow-calf stage, where producers maintain a herd of mature cows and mate them for raising calves from birth to six or seven months of age. Most producers calve in the spring, with each cow usually giving birth once a year.

The typical Saskatchewan cow-calf operation has a relatively small herd, with the majority of producers having less than 100 cows, and often has more than one farming enterprise in their operation. Mixed farms often have land dedicated to growing grain and/or forage to generate revenue and diversify their operation. Cow-calf operators have no market power and are mostly at the mercy of those who control the production stages above them (Carlberg, 1999).

The second phase is the backgrounding stage, which is a developing stage in the feeding process as feedlots want to specialize in feeding heavier cattle to increase the turnover of animals through the feedlot. Backgrounding is taking newly weaned calves and feeding them a grower ration until they are large enough to be put on a finishing ration. Backgrounding adds frame size to the animals while not adding a lot of fat (SAF, 1997). This prepares the calves for the feedlot so calves respond quickly to finishing rations, minimizing the finishing time. Although, backgrounding is becoming more common, not all calves are backgrounded. Large framed calves that typically grow into very large finished animals may be put directly into a feedlot for finishing.

The third feeding stage is the finishing stage, where backgrounded and large framed calves are fed finishing rations for fattening, and when finished, are sent for slaughter. In Canada, the average live weight at slaughter for steers is about 590 kilograms, while the average weight for heifers is about 550 kilograms. In 1999, approximately 90% of the animals produced for slaughter in Canadian feedlots graded CANADA A, AA, AAA & Prime - the highest quality categories within the Canadian grading system (Canada Beef Export Federation, 2001).

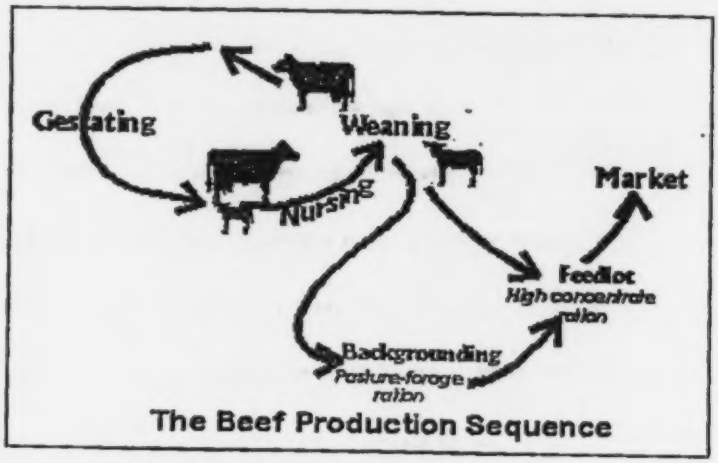

Figure 2. 3 Cattle Production Cycle

Finished cattle are moved to a packing plant for slaughter and some processing. Usually the animals are processed into half carcasses or boxed beef. Boxed beef is beef that has been cut into portions by the packer, vacuum sealed, and shipped out in boxes. This process removes unwanted bone and fat, which helps reduce transportation costs. In Saskatchewan, there is one large slaughter plant in Moose Jaw that slaughters 700 - 800 head per day, while in Alberta, there are several plants, with the two largest located in High River and Brooks, each slaughtering 3,700 – 4,000 head per day.

The wholesale/retail sector takes the meat from the slaughter plants and prepares it for sale to consumers. Wholesalers and retailers are very important for relaying

information about consumers' preferences to slaughtering plants and back through the supply chain. Wholesalers provide feedback to the slaughter plants on the types of meat characteristics that retailers want, and slaughter plants pass this information to cattle feeders by offering price premiums for animals yielding the desired cuts.

A noticeable trend in the beef supply chain suggests that as animals move through the stages of production, up to processing, there is increased concentration and specialization. At each level there are fewer operations handling larger numbers of animals. Very few producers carry out all the feeding stages on their own farm, from cow-calf to finishing. Some cow-calf producers do some backgrounding, and some others may only background cattle, but many feedlots have become very specialized and will feed cattle only over 363 kg.

2.4 Pasture

Pasture types can be grouped into two general categories, native and tame. Native pasture is unimproved land that has not been broken and re-seeded or fertilized. There has been a downward trend in the amount of native pasture in Saskatchewan over the last 40 years. In 1961, there were 7.7 million hectares of native pasture (Smoliak et al., 1990), and by 1996, only 5.1 million hectares of native pasture remained. A large decline in the amount of native pasture occurred in the mid to late 1970s due to high grain prices which attracted many producers to convert these lands into annual crop production. In the last two decades, there have been several years of poor grain prices and seeding this marginal land to grain has not proven sustainable nor profitable. An added stimulus was the removal of the Western Grain Transportation Act (WGTA) in 1995 which increased freight costs, and made producers look for more profitable uses of their land, including seeding the land to tame grasses.

Once native grassland is fertilized, or once land has been seeded to grass for grazing, it is classified as improved pasture or tame pasture. While native pasture acreage was decreasing, the amount of tame pasture was increasing. In 1961 there were 0.57 million hectares, and by 1996 1.2 million hectares of tame pasture existed, implying that some native pasture, or grain land, was converted to tame pasture over this time period (Coghill, 1998).

2.4.1 Pasture Management

In pasture management, like most other enterprises, productivity depends on the level of investment of time and money. Many factors affect forage productivity, which in turn, has a significant impact on cattle performance. Soil texture and fertility, climate, and grass species are some of the main determinants (Emmick et al., 1993)

In a specific grazing system, the soil texture is taken as a fixed input which cannot be immediately altered, but through different management techniques and over time, can be improved. Having and maintaining high quality, well aerated soils is essential to produce high herbage yields. A very important factor related to soil type, is using the appropriate grass species. There are many grass species available, but each species performs differently under similar soil and climatic conditions (Cohen, 2000 Personal Communication). Finding a grass species or combinations of grasses that perform the best at a certain location is critical for maximizing cattle performance.

Animal performance on pasture is directly related to forage quality, which includes amount and palatability of the forage, nutrient concentration, and digestibility. The quality of pasture forage is a function of three separate but related factors; the kinds of plants present, their stage of maturity, and the time of year. Cattle producers should

incorporate species and management systems that have cattle grazing the different grasses at optimal times to maximize cattle performance (Emmick et al., 1993).

Pasture productivity includes, land, climate, and grass species, but cattle productivity can also be improved with variables solely controlled by managers. The grazing system, watering system, and stocking rate are all very critical variables chosen by managers. Different grazing and watering systems will require different levels of investment by producers. Managers must decide if they want to invest time and money into higher maintenance more productive systems, or lower maintenance less efficient systems. Stocking rate is also very critical, and possibly harder to manage because of the changes in weather from year to year. A proper stocking rate is critical to maintaining the long-term productivity of the pasture. High stocking rates can lead to overgrazing which can cause the loss of highly productive and palatable grasses because of the continuous stress on the plants from the grazing animals (Smoliak, 1990).

Water and water quality are extremely important parts of a grazing plan, and the higher the quality and more accessible it is to the livestock, the better. However, this does not mean that every paddock requires a separate water source. In some cases, a water source can be placed at a central location and serve 2 or more paddocks. The primary concern is making sure that water is available to the livestock at all times, and that it is of adequate quantity and quality.

The last major management decision that must be made is the type of grazing system to be used. The three most common systems include rotational, continuous and complementary grazing.

2.4.1.1 Rotational Grazing

In rotational grazing systems, livestock utilize two or more grazing units or paddocks that are alternately grazed and rested during the time period in which grazing is allowed. Rotational stocking requires pastures to be subdivided into individual grazing units called paddocks. Individual paddocks are grazed one at a time, in a planned order, with livestock occupying each paddock long enough to harvest the existing forage, but generally not so long as to allow grazing of regrowth to occur. After each paddock is grazed to the desired forage stubble height, it is allowed to regrow and regain vigor before being grazed again (Emmick, 1993). In a well-managed rotational stocking method, the forage supply is constantly monitored and adjustments to the stocking rate are made by increasing or decreasing the amount of pasture acreage grazed during a particular time period.

Generally, development costs for water, fence, and management are greater for rotational grazing than for continuous grazing. However, because it is easier to maintain an effective balance between forage demand and forage supply, rotational stocking methods generally promote higher forage yields, more uniform levels of forage quality, improved harvest efficiencies, maintain long-term pasture productivity and as a result, maximize livestock production per unit of pasture area (Owensby, 1987).

2.4.1.2 Continuous Grazing

In continuous grazing systems, livestock have the continuous or uninterrupted use of a unit of grazing land throughout the time period in which grazing is allowed. As commonly practiced, the continuous stocking method can be described as a minimum management practice. A set number of animals are turned out on a given pasture and

allowed to graze for as long as the forage supply lasts. Although development costs for water and fencing are low with this method, it is extremely difficult to control the grazing events, and thus, it is nearly impossible to maintain an effective balance between forage demand and forage supply. When stocking rates are set too high, animal nutritional requirements are not met and individual animal performance is reduced. When stocking rates are set too low, forage is wasted and production per unit area is reduced. In either case, the result is often a highly variable forage quality and an inefficient conversion of forage into a saleable product (Emmick, 1993).

With the increased amount of wasted forage and highly variable forage quality associated with the continuous stocking method, it is not recommended for livestock operations where maximizing production per unit area is the primary objective. However, for many livestock operations where forage supply exceeds forage demand, and there is no demonstrated need for the surplus forage, continuous stocking may be an appropriate method.

2.4.1.3 Complementary Grazing

In complementary grazing systems, livestock utilize two or more grazing units where each grazing unit is used for only one portion of the season and rested until the next grazing year. Complementary grazing systems often include the use of native range, tame pasture, and stored forages to meet the cattle's nutritional requirements throughout the season. One forage type is used at a time when other forages fail to meet the cattle's nutritional requirements. It is optimal to use different grass species that grow at different rates throughout the season to help extend the grazing period and keep forage quality constant over the entire period. This system will either allow operators to

carry more animals on a parcel of land, or decrease the amount of land required to sustain the herd (Owensby, 1987).

There are also simple complementary grazing systems that only use two grasses. An example of a good complementary grazing system includes Crested Wheatgrass (CWG) and Russian Wild Ryegrass (RWR). Crested Wheatgrass grows early in the spring and is tolerant to early grazing, but grows much slower later in summer. Russian Wild Ryegrass combines well with the CWG because RWR is a good late season forage that remains palatable and has high nutritive qualities well into the fall.

2.5 Grasses

2.5.1 Crested Wheat Grass

Crested Wheatgrass (Agropyron cristatum) is a cool-season perennial species that was introduced to North America from Eastern Europe and Asia in 1898. Crested Wheatgrass is a bunchgrass that possesses a deep, extensive root system. It is particularly well adapted to sandy soils, it is intolerant of spring flooding and saturated soils, and is moderately saline tolerant. It grows best in soils that are moderately coarse to medium in texture with a minimum depth of ten inches. It can be used as hay or pasture but is best adapted for early spring pasture (Tremblay, 1999).

2.5.2 Russian Wild Ryegrass

Russian Wild Ryegrass (Psathyrostachys junea) is an introduced cool-season bunchgrass. The original seed was brought to the United States from Siberia in 1927. Russian Wild Ryegrass is deep rooted, drought resistant and salt tolerant; however, it has poor tolerance to spring flooding and saturated soils. Growth begins early in spring, but

also provides good late season forage. Stands may be slow and somewhat difficult to establish, but once established are more drought resistant and longer-lived than CWG. Palatability is good, and nutritive qualities are excellent throughout the season because of its high digestibility and relatively constant crude protein level (Tremblay, 1999).

Chapter 3 Theoretical Framework

3.1 Introduction

This chapter explains the economic theory used in the thesis. Firms must decide what to produce, and how they are going to produce it. Depending on an individual's preferences, many different criteria can be used to determine the best alternative, but depending on the criteria used, it can lead to very different results.

3.2 Production Theory

"Production is the process of transforming inputs into outputs," (Jehle, 1998). The state of technology determines and restricts the possibilities of combining inputs to create outputs. In a simple model with two outputs, a production possibilities frontier (PPF) can be developed. This frontier is the locus of points showing the maximum attainable output of one commodity for every possible volume of output of the other commodity, for a given level of input resources and technology restrictions. The shape of the production function for an output depends on the nature of the underlying physical, chemical and biological characteristics, but generally the PPF is negatively sloped and bowed outwards because production processes exhibit decreasing returns to scale. The negative of the slope of the PPF is called the marginal rate of transformation, which is the rate at which the firm can transform one good into another by transferring production resources from producing one good to the other. As an example, the PPF for

beef and grain (Figure 3.1) bows out, and the marginal rate of transformation increases as more and more beef is produced, and less and less grain is produced. The optimum level of production of grain and cattle occurs where the slope of the production possibilities frontier is equal to the negative of the ratio of the respective product prices[1].

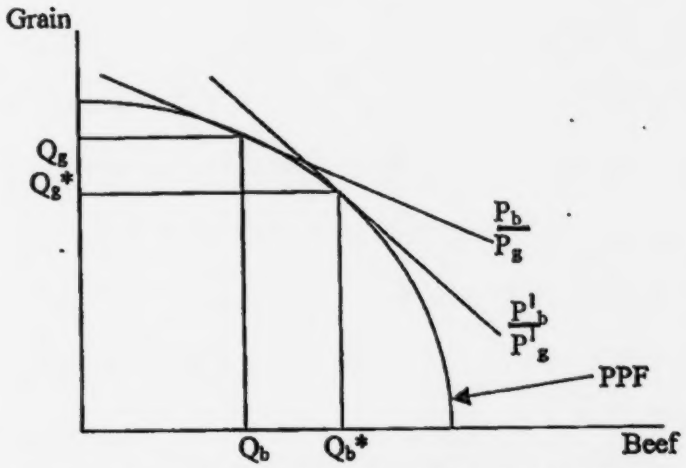

Figure 3. 1 Production Possibility Frontier for Beef and Grain

If the respective prices for grain and beef were originally at P_b and P_g, the amount of grain and beef produced would be Q_g and Q_b, respectively. However, recently the prices of beef and grain have been changing, such that the price of beef has increased while the price of grain decreased, causing the ratio of beef price to grain price (P'_b/P'_g) to increase, which is represented as a steeper line. This results in an increase in the production of beef from Q_b to Q_b^* and a decrease in grain production from Q_g to Q_g^* given the quantity of inputs available and level of technology being used.

[1] For a more detailed development of a PPF and general equilibrium see Binger and Hoffman, 1988, Chapter 14.

3.3 Cost Function

Once a producer has decided what to produce, a decision must be made regarding the types and proportion of inputs to use in production. Output expressed as a function of input is called a production function, typically expressed as:

$$q = f(x_1, x_2, \ldots, x_n), \tag{3.1}$$

where q is the units of output, and $x_1, x_2, \ldots, x_n$ are the inputs.

There are usually several combinations of inputs that can be used to create a product, but producing a reasonable amount at a competitive price is the key to a firm's success. In an industry that is perfectly competitive, any type of cost savings over what is currently being used will give some profit, at least in the short-run, until other producers adopt these same practices and compete away the new profits. Perfect competition is a market form that involves many firms, each having similar information, are price takers, all produce a homogeneous product, and have free entry and exit from the industry (Lipsey, et al., 1985). Theoretically, in the long-run, profits in a perfectly competitive industry are zero because of the above assumptions.

All stages of the cattle feeding industry approach the characteristics of a perfectly competitive industry. Cattle producers, for the most part, are price takers. At the time of the production decision or investment, they do not know the price they will receive for the product, but their production decisions will not affect the market price. They also do not know exactly how much they will have to sell because of production uncertainties (e.g. weather conditions, death loss). In such cases where firms have chosen their level of output, they can profit maximize by minimizing costs for their operation because revenue will be fixed, and costs will be the variable easiest to control.

Producers optimize by minimizing costs subject to their production function. For example, a producer is going to search for the cheapest way to feed a group of calves for market. This follows from the PPF, that as the price of cattle increases relative to grain, the producer will shift land, labour, capital, etc, from grain to beef production.

The cattle producer will use inputs $x_1, x_2, \ldots, x_n$, with corresponding costs of w_1, $w_2, \ldots, w_n$.

Therefore, the producer's cost function (C) is:

$$C = w_1x_1 + w_2x_2 + \ldots\ldots + w_nx_n + F, \qquad (3.2)$$

where, F = fixed costs of the operation

Economic cost can be defined in two ways. One way defines cost as the market value of all inputs used in production. A second definition says that economic cost is the market value of the next best alternative employment of resources used in production (Binger, et. al. 1988). This definition values inputs as an opportunity cost, which is its forgone value. Therefore, all inputs have a cost whether the firm pays cash for them (explicit costs) or foregoes other revenue (implicit costs).

3.4 Risk and Uncertainty

In most industries, and especially in the cattle feeding industry, very few things are known with certainty. Decisions are made before outcomes are known and outcomes usually occur after a long period of time, thus leading to uncertainty. Uncertainty occurs when the possible outcomes, or the probabilities of the outcomes are not known. In economic applications, uncertainty is often dealt with in terms of risk analysis. A risky situation is a situation where all possibilities and their joint probability density functions are known. By making assumptions, uncertainty can be analyzed as risk by assigning probabilities to the different outcomes. The common outcomes are

given a probability of something ≥ 0 and ≤ 1, while all other unlikely or unknown events are given a probability of zero.

Cattle producers face several risks, but in general, risk can be grouped into two broad categories; business risk and financial risk. Three major sources of business risk are market risk, technical risk, and legal and social risk. Market risk relates to uncertainty in the markets, such as the selling price of animals or the cost of inputs. Technical risk relates to production risks, such as the influence of weather, disease, death and changes in technology, which are beyond the producers control. Legal and social risk includes the risks of being in business. This includes such things as lawsuits if cattle were to damage neighbor's a property, or having disputes with employees that disrupt production plans. Cattle producers are subject to all three types of business risk as well as financial risk. Financial risk is defined as, "the added variability of net returns to owner's equity that results from the financial obligation associated with debt financing" (Brown 1998). This risk is mainly associated with the availability of credit, and changes in interest rates on debt.

3.5 Risk Analysis

Virtually everyone wants to earn more money, but earn it in a relatively comfortable way. In other words, they do not want to risk losing a large amount of money for the chance of earning a little more. Thus, there is a tradeoff that exists between increasing profits and increasing the risks involved in doing so.

These trade-offs, and the willingness to incur risk are different for each individual. Individuals normally fall into one of three groups, namely risk averse, risk neutral or risk loving. These people prefer more money, but when faced with risky situations, they make different choices.

The expected value of a risky situation can be defined as the mean of a distribution of possible outcomes. In the general case, the expected value for a discrete random variable that can take on values of $x_1, x_2, \ldots, x_n$, with associated probabilities $P(X = x_i) = f(x_i)$ can be expressed mathematically as (Ramanathan, 1992):

$$E(X) = \sum_{i=1}^{n} [x_i f(x_i)] \tag{3.3}$$

Risk averse individuals typically prefer a smaller guaranteed amount, than to participate in a risky situation that has a relatively higher expected value. Risk neutral people are indifferent between taking a gamble with an expected value equal to a guaranteed amount. While risk loving people prefer to take gambles rather than receive a guaranteed amount. These different risk preferences are illustrated in Figure 3.2 which shows an individuals utility function for income or money. In order for a utility function to exist, certain restrictions as to rationality and consistency of choices among risky alternatives must be met. These properties can be stated as the axioms of: Ordering – for any two distinct action choices A_1 and A_2, either A_1 is preferred to A_2, or A_2 is preferred to A_1 or the decision maker is indifferent between them. Reflexivity – for any action choice A_1, the decision maker is indifferent between A_1 and A_1 its exact match. Transitivity – for any three action choices A_1, A_2, A_3, if the decision maker prefers A_1 to A_2 and A_2 to A_3, then he/she prefers A_1 to A_3. Certainty equivalent – for any action choice A_1 there is some probability $p \in [0,1]$ such that the decision maker is indifferent between A_2 and $[(p \times A_2) + (1-p) \times A_n]$. This means that if indifference does not hold at either extreme, then it must hold for some intermediate value of p. Monotonicity – for all probabilities $p^0, p^1 \in [0,1]$, $[p^0 \times A_1 (1-p^0) \times A_n]$, is preferred to $[p^1 \times A_1, (1-p^1) \times A_n]$ if and only $p^0 > p^1$. This implies A_1 is preferred to A_n, and rules out the case of

indifference among all A's. Substitution – if A_1 is preferred to A_2, and A_3 is preferred to some other risky choice, then a risky choice [p x A_1 + (1-p) x A_3] is preferred to [p x A_2 + (1-p) x A_3]. This means that when a particular gamble is considered, the decision maker is concerned only with the effective probabilities assigned to each outcome. If these axioms hold, it follows that the optimum risky choice for an individual is that which maximizes expected utility (Schoney, 1998).

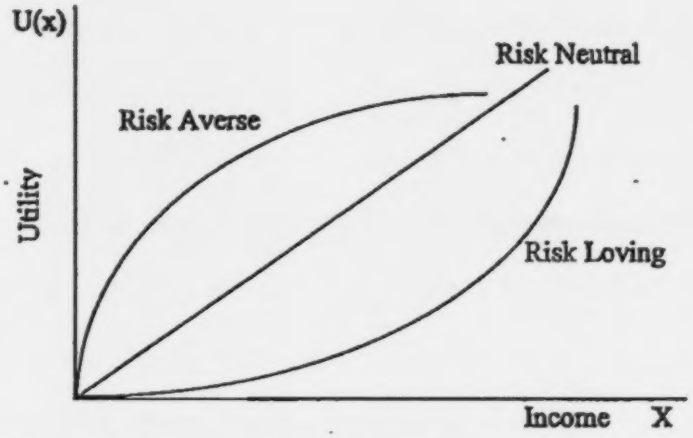

Figure 3. 2 Utility Functions for Individuals

A risk averse individual has a concave utility function which displays diminishing marginal utility of money. As this person earns an extra dollar, they receive more utility, but by a smaller increase than received from the previous dollar earned. This concave function also displays the disutility of the risk associated with earning extra income. This disutility will be further explained in Figure 3.3. Risk neutral individuals have constant marginal utility, and are indifferent to risk. This is shown as a straight line, with respect to income utility. Their utility is a function of only the expected value of the alternatives, with risk having no effect on their choices. The risk loving individuals have a convex utility function. As income and variance increase, utility increases at an increasing rate because both have positive effects on utility.

Discussion about risk aversion requires the understanding of risk premiums and certainty equivalents. A certainty equivalent is a guaranteed level of income that makes a decision maker indifferent between this level of income and a risky prospect. The risk premium is the difference between the expected monetary value of the risky situation and its certainty equivalent (Binger, 1988). In other words, the risk premium is the amount of expected income a producer would be willing to give up so as to not participate in the risky situation. These concepts are shown in the Figure 3.3.

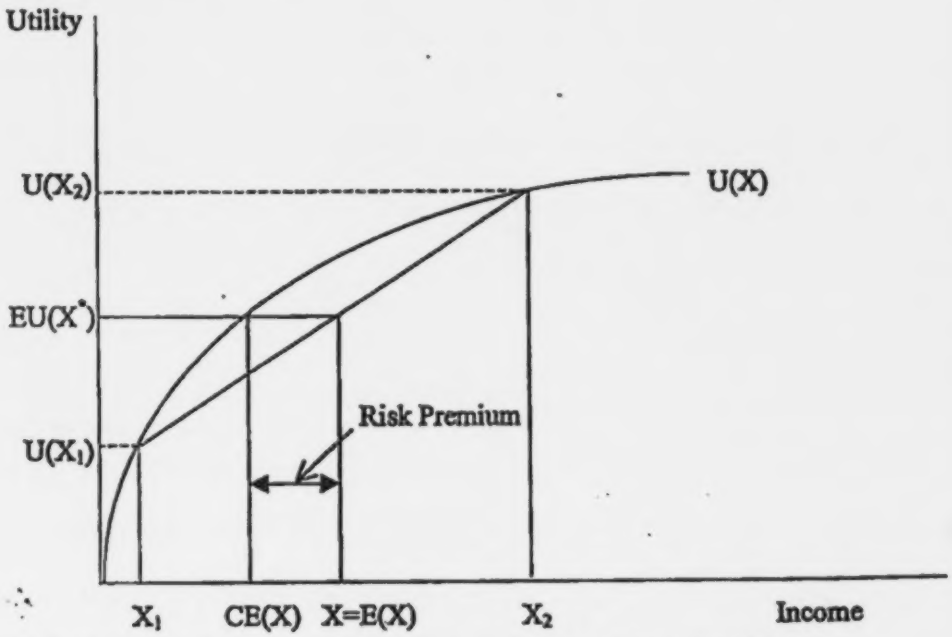

Figure 3. 3 Expected Value and Certainty Equivalent for a Risk Averse Individual

Figure 3.3 shows the concave utility function for a risk averse individual. X_1 and X_2 are two outcomes each with equal likelihood of occurring. Thus the expected monetary value of this risky situation is: $E(x) = .5(X_1) + .5(X_2) = X$.

The certainty equivalent of this situation is defined as: $U(CE(x))=EU(x)$. This means the certainty equivalent of x is the amount of sure wealth which makes the

decision maker indifferent between CE(X) and being in a risky situation with two equally likely outcomes X_1 and X_2.

The risk averse person derives less utility from the expected value of the gamble than from having the same amount for sure (i.e. EU(X)<U(X)). The risk premium ($\prod$) is the amount a risk averse person will pay to avoid risk (Binger, 1988):

$$\prod(X) = E(X) - CE(X) \tag{3.4}$$

As risk aversion increases, CE(X) will decrease and $\prod(X)$ will increase.

3.5.1 Measuring Risk Aversion

A common method used to measure the degree of risk aversion is the Arrow-Pratt measure of absolute risk aversion (ARA). It is defined as:

$$R_a(w) \equiv \frac{-u''(w)}{u'(w)} \tag{3.5}$$

where: $R_a(w)$ is ARA coefficient
u''(w) is the second derivative of the utility function with respect to wealth
u'(w) is the first derivative of the utility function with respect to wealth

In general, the first derivative of the utility function [u'(w)] is positive which implies that more money is preferred to less, and the second derivative [u''(w)] is negative, which reflects the diminishing marginal utility of income. Therefore, for risk averse individuals, this coefficient is positive (Binger, 1988).

The larger the ARA coefficient for an individual, the more risk averse they are. This can be seen if the second derivative becomes smaller (bigger negative number), the utility function will be more flat at lower levels of income. This means the certainty equivalents decline as the person becomes more risk averse, thus increasing the risk premium.

Another measure of risk aversion is the relative risk aversion (RRA) coefficient, which is defined as:

$$R_a(w)^*w \qquad (3.6)$$

This measure scales the ARA for wealth (w). The ARA is usually decreasing with respect to wealth. If a particular gamble is the same, but the income has increased, individuals will normally be more willing to accept the gamble. As with the ARA, higher RRA values reflect increasing risk aversion. These measures are particularly useful for hypothesis testing regarding responses of changes in risk aversion as wealth is varied (Carlberg, 1999).

Both the ARA and the RRA measures are useful in selecting which, among the group of possible production options, individual producers with particular risk aversion characteristics would choose to implement.

3.6 Mean Standard Deviation Framework

The Mean-Standard Deviation (MSD) framework, ranks risky alternatives based on the first two moments of the distribution of payoffs. The mean is the expected value of the outcome, and the standard deviation or variance is a measure of risk for an alternative (Meyer, 1987).

MSD analysis is widely used in whole farm planning, but its usefulness depends on the nature of the distribution of returns and the decision maker's preferences (Kramer, 1981). The MSD criterion is only valid when the distributions are normally distibuted or the decision maker's utility function is quadratic (Barry, 1984). These conditions are unlikely to be fulfilled in many cases because many risks in agriculture have a skewed frequency distribution, and a quadratic utility function implies that risk aversion increases with wealth. Further, it implies that the decision maker is indifferent

to skewness or peakedness, or that they are indifferent to negative risk versus positive risk. These underlying assumptions reduce the validity of MSD analysis.

The expected value of profits can be calculated as:

$$E(\pi) = \frac{\sum_{i=1}^{n} \pi_i}{n} \tag{3.7}$$

where, $\prod_i$ is profit in circumstance i, and n is the total number of circumstances. While the standard deviation of profits, is computed as:

$$\sigma_\pi = \sqrt{\frac{\sum_{i=1}^{n} (\pi_i - E(\pi))^2}{n-1}} \tag{3.8}$$

Risk averse individuals prefer less risk to more. Thus if two alternatives have the same expected return, the one with the lower standard deviation will be selected. Likewise, if two alternatives have the same standard deviation, the one with the higher mean or expected value will be chosen. The locus of points showing the highest level of return for a given level of risk, or the minimum risk alternative for a given level of return, is called the Risk Efficient Frontier (REF) (Figure 3.4).

Points on the REF cannot dominate others because each point has a different level of risk and return. The investments on the REF are considered to be part of the risk efficient set. To choose among the different points on the REF, an individual's risk preferences must be introduced. The following graph shows the REF with different utility curves. These indifference curves (I_1, I_2, I_3) show the different risk preferences and points that these very specific individuals would choose to operate at.

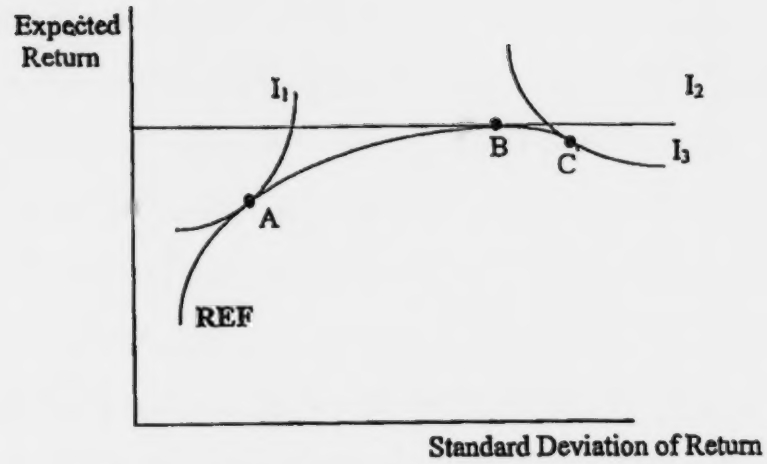

Figure 3. 4 Risk Efficient Frontier

Individuals will maximize utility at the point where their indifference curve is tangent to the REF. This tangency ensures they are at an efficient operating point, and at the highest possible level of utility, given the nature of this utility function. I_1 represents a risk averse individual that chooses a lower return in order to avoid risk. This individual will choose point A. The utility function I_1, gets steeper as risk increases, which implies that in order to take on more risk, this individual will need increasing units of income as the risk increases. A more risk averse person will choose a point with lower risk, and income, to the left of point A, while a less risk averse person will be willing to take some more risk to increase income and be to the right of point A. Individuals that choose to operate to the left of point B are risk averse. People who choose point B are risk neutral, and are indifferent to risk. These latter individuals maximize expected profit, and for them the level of risk or income variability has no effect on their decision. These individuals have a straight utility function because there is no trade-off between risk and income, and all utility is derived from the level of expected income. To the right of point B, are the risk seekers. These individuals gain

utility from taking or accepting risk. Therefore, as risk increases, their utility function becomes flatter. As risk increases, these individuals are willing to accept gambles with lower expected returns, so to be able to participate in higher risk situations.

Utility functions of decision makers are usually not known, which makes it very difficult to locate the exact point where people will decide to operate. Also, some of the assumptions of the MSD model are weak, and this reduces the usefulness of the MSD model. Other methods exist to choose the risk efficient investment alternative, and the next method to discuss is stochastic dominance.

3.7 Stochastic Dominance

Stochastic dominance is often chosen over the MSD framework for risk analysis because it reduces the restrictions placed on a decision maker's utility function. It uses pairwise comparisons of probability distributions from a finite set of choices in order to determine if a production option is inefficient and should be discarded from the efficient set. "Stochastic dominance allows the ranking of probability distributions for different classes of risk attitudes" (Kramer, 1981).

Stochastic dominance analysis uses the cumulative density functions (CDF) of the risky outcomes to compare the alternatives. A CDF is the sum of the area under the probability density function to the left of a specified point. Mathematically, for the function f(x), the CDF is expressed as:

$$F(x) = \int_{-\infty}^{x} f_{x_1}(z)dz \qquad (3.9)$$

Graphically the resulting CDF is,

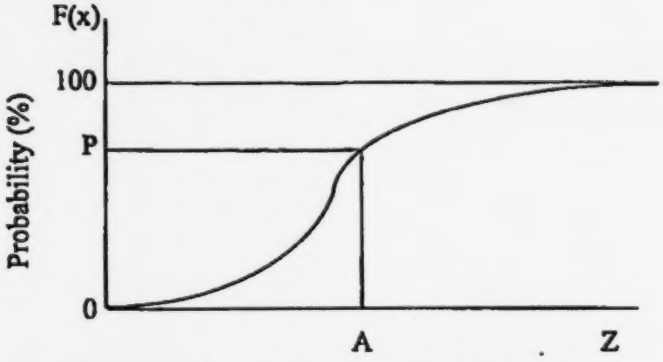

Figure 3. 5 Graph of a Cumulative Distribution Function

This graph shows the cumulative probability distribution on the Y-axis, for different possible outcomes (Z) from using one production option. It is interpreted as: the probability of earning an income value of A or less, is P.

3.7.1 First Degree Stochastic Dominance

First and second degree stochastic dominance are the simplest and most commonly used risk efficiency criteria. First degree stochastic dominance (FSD) has only a single restriction, that more is preferred to less, i.e., decision makers must have positive marginal utility for income.

Under FSD, an alternative with an outcome distribution defined by cumulative probability distribution F(y) is preferred to a second alternative with cumulative distribution G(y) if

$$F(y) \leq G(y) \tag{3.10}$$

for all possible values of y and there is a strict inequality for at least one value of y. This states that, F(y) FSD dominates G(y) if and only if the probability of being below some

income value y is less than or equal to the corresponding G(y) values for all values of y (Schoney, 1998) (Figure 3.6).

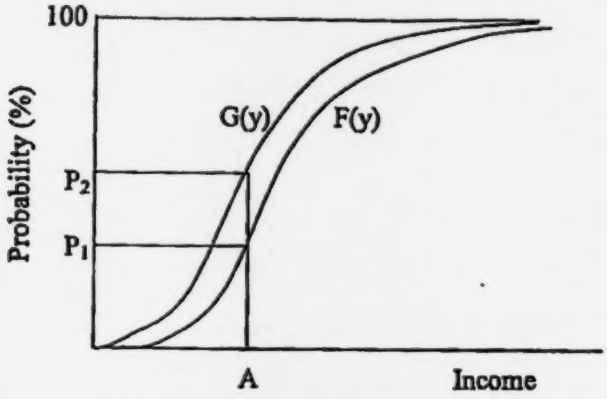

Figure 3. 6 First Degree Stochastic Dominance

This graph shows F(y) dominating G(y). At income level A, the probability of falling below this income level is P_1 for F(y), and P_2 for G(y). Obviously F(y) is preferred because this is the case for all levels of income.

3.7.2 Second Degree Stochastic Dominance

Second degree stochastic dominance (SSD) allows for more discrimination among risky prospects when the CDFs intersect. In addition to positive marginal utility of income, SSD requires that the marginal utility of income is diminishing.
SSD criterion is defined as:

$$\int_{-\infty}^{\infty} F(y)dy \leq \int_{-\infty}^{\infty} G(y)dy \qquad (3.11)$$

This expression can be restated as; F(y) SSD dominates G(y) if and only if the sum of the probabilities of being below some income value, y, is less than or equal to the corresponding G(y) values for all values of y, and there is a strict inequality for at least one value of y.

The SSD criterion compares intersecting areas under the CDFs. A distribution function F(y) dominates G(y) if it lies more to the right in terms of differences in area between the CDF curves cumulated from the lower values of uncertainty quantity (Anderson et al., 1977). This is depicted in Figure 3.7 where the area marked by a, is greater than the area marked by b.

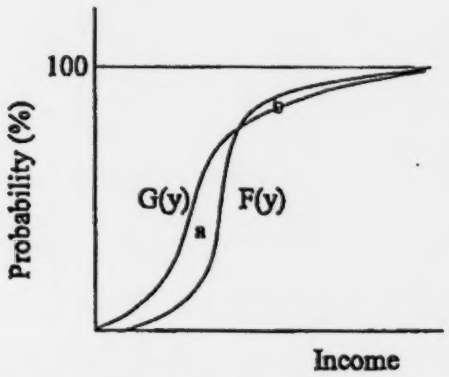

Figure 3. 7 Second Degree Stochastic Dominance

3.7.3 Generalized Stochastic Dominance

Discriminating between risky prospects with the assumptions of first and second degree stochastic dominance does not always lead to definitive results. Stronger assumptions about risk aversion coefficients are often required. Generalized stochastic dominance (GSD) provides a method of predicting the choice between two distributions when it is only known that the decision maker's risk aversion function lies between arbitrarily set upper and lower bounds defined over a given domain of monetary outcomes (Zentner et al., 1981). To use GSD, a utility function has to be identified which minimizes

$$\int_0^1 [G(y) - F(y)]U'(y)dy \qquad (3.12)$$

subject to the ARA of the utility function falling between the lower and upper bounds which are arbitrarily set. RISKROOT is a software program that computes these bounds to help identify the dominant distribution given the assumptions about the decision maker's risk attitude. This program is described in the next chapter.

Chapter 4 Methodology and Empirical Framework

4.1 Introduction

This chapter outlines the methodology and assumptions used to empirically analyze different backgrounding and finishing options using the theoretical framework described in Chapter 3. The analysis uses a simulation model, a spreadsheet model, and a software program that ranks the different production options using stochastic dominance principles.

4.2 Overview

The objective of this analysis was to identify a method of feeding calves that is risk efficient for farm managers. It is based on a situation where a farm manager wants to diversify or expand his/her operation into backgrounding cattle with the possibility of finishing them. In this case, the producer wants to consider the options that exist for feeding calves on pasture, by converting grain land to pasture, and compare the returns from grazing to the returns of having calves custom fed in large feedlots. There are many different alternatives to consider as part of the grazing system, such as, should the manager fertilize the pasture, provide supplement for the calves, try to finish the calves on pasture or simply background and sell the calves. To choose the best production alternative, distributions of economic profit have to be developed for each alternative and compared to all others. The economic profits of each trial will vary because of production variation, different input costs, and

uncertainty of output prices.

Historical price data for the 1978 – 1998 period together with location specific weather data were used to generate production distributions for each feeding option. The trials were run at three locations across Saskatchewan to determine differences in performance due to soil and climatic conditions. The three locations were, Swift Current, Watrous, and Aylsham. Swift Current is located at $50^0$12'N $103^0$48'W, Watrous is located at $51^0$40'N $105^0$28'W, and Aylsham is located at $53^0$12'N $107^0$44'W. The environmental conditions and productivity differences among locations are shown in Appendix C.

4.3 Production

The GrassGro simulation model (Moore et. al., 1997) was used to estimate cattle and forage production on pasture, as well as feed consumption by the animals in drylot. GrassGro is a computer simulation model that predicts pasture and cattle growth from daily climate data. Originally developed for Australian conditions, GrassGro has been adapted to North America (Cohen et al., 1995). Species files for 15 native and seeded pasture grasses and legumes common to the Canadian Prairies have been developed and validated. (Cohen et al., 1995, German, 1999, Meyers, 1999). The model predicts daily growth of pasture and weight gain of cattle on pasture throughout the grazing and winter feeding periods. To do this, the user inputs the grass species or mix of grass species, top soil and subsoil textures, daily rainfall, daily temperature, stocking rate, and the grazing system. The user also chooses the species, class and breed of livestock, as well as the length of the grazing and winter feeding periods. To input weather data, users choose a location from the locality menu and GrassGro automatically accesses weather data for the location from Environment Canada archives. GrassGro also allows the option of

supplementary feeding the livestock on pasture. For the winter feeding period, or any drylot period, the amount and quality of feed can be inputted (or default quality values can be chosen) and given the length of the feeding period, the model will predict the weight gain of the animals. Alternatively, the user can choose a target weight, which the animals are required to reach by a given date, and the GrassGro model will calculate the liveweight and amount of supplement required.

Given the same conditions, different breeds of animals will perform differently, and the GrassGro model adjusts for this once the user has specified the breed of cattle being fed. It is more common that British breeds, such as, Hereford and Angus, are backgrounded rather than the exotics, such as Charolais and Simmental. The main reason is framesize. During the backgrounding period, animals are fed a grower ration, which is not always needed for exotic animals. This study only considers backgrounding and finishing of British breed calves.

In this study, historic weather data were used at each location from 1978 to 1998 in a daily time step. There were also trials that used different soil textures. Some trials used a loamy sand topsoil with a sandy loam subsoil, while the other trials used a loam topsoil with a sandy clay loam subsoil.

The grass species and grazing system selected were the same for each location. Every grazing trial was based on one section of land, or four, 65 hectare paddocks. In each location a complementary grazing system was used, with two paddocks of CWG and two paddocks of RWR. The complementary grazing system was used because it has been shown to be the most productive, and more appropriate for intensive grazing operations. Once all of the variables are specified, the model will simulate the amount

of herbage production each day, and if the pasture is being grazed, it will estimate the weight gain of the cattle.

GrassGro is able to simulate the growth of pasture and cattle over consecutive years. This means that the amount of herbage left at the end of one year has a significant impact on the amount of herbage available at the beginning of the next year. In this study, each trial was run for 21 years to generate 21 different production possibilities.

4.4 Feeding Scenarios

There were two sets of trials, grouped into summer and fall trials. The summer trials were similar at each location, while the fall trials differed by location. For example, at Swift Current, some fall grazing trials were conducted to determine the returns of grazing calves late into the fall rather than having them in a drylot during fall and winter. These trials were not run in the more northern locations because of the potential for excess snow for grazing.

4.4.1 Summer Trials

The summer trials were defined around three main factors, namely, fertilizing the pasture, supplementing the calves, and soil texture. Combinations of these factors were run and the returns compared to feeding the calves in drylot.

The summer trials for the three locations were:

Trial #1	No supplement, fertilizer, sandy soil,
Trial #2	No supplement, fertilizer, loam soil,
Trial #3	No supplement, no fertilizer, loam soil
Trial #4	Energy supplement (barley), fertilized, loam soil
Trial #5	Protein and energy supplement, fertilized, loam soil, and
SumDry	Calves fed in drylot

In all summer trials, calves were bought on the 15th of May at a weight of 295 kgs, and taken off pasture on September 30th. The calves grazed one paddock at a time for a period of about 34 or 35 days. The animals grazed CWG paddocks first, and then grazed the RWR paddocks. The weight of the calves at the end of the grazing season is different each year depending on the weather conditions which influenced forage production. For all trials, the stocking rate was adjusted, so after the model is run for 21 years, the average weight of the calves at the end of September was 363 kg.

In the trials where calves were supplemented, they received 2 kg/head/day for the entire summer. The energy supplement was barley, and the protein and energy supplement consisted of 0.5 kg of canola meal and 1.5 kg of barley.

4.4.2 Fall Trials

In the fall trials, the calves spent some time in a drylot. While in the drylot, they were fed one of two rations. These rations were termed, Drylot 1, and Drylot 2. These rations were similar except that animals offered Drylot 1 were fed to gain 0.4 kg/day, and calves offered Drylot 2 were fed to gain 0.8 kg/day. The Drylot 1 ration consisted of 80% alfalfa hay and 20% barley, while the Drylot 2 ration was 70% hay and 30% barley. These rations were included to determine how the calves would gain in the summer, when being put on pasture at different weights. The calves fed Drylot 1 were normally brought up to a weight of approximately 363 kg, but some trials did involve finishing them. Animals fed Drylot 2 were finished on pasture with barley supplement.

In the feeding and grazing trials, there were a total of three feed sources used, namely alfalfa/grass hay, barley and canola meal. The nutritional parameters of these feeds are shown in Table 4.1.

Table 4.1 Feed Nutritional Parameters

Feed	Dry matter %	Dry matter digestibility %	Metabolizable, energy: dry matter Mcal.	Crude protein %
Alfalfa/grass hay	87	60	10.48	18.2
Barley	87	90	15.84	12
Canola meal	92	85	12.26	44

Source: (Cohen, 2000)

For fall trials, the soil was assumed to be a loam texture which was fertilized annually. There were two trials at each location which were the same. In these trials, animals were bought at the end of September and put into drylot on either the Drylot 1 or Drylot 2 ration, and then backgrounded or finished the next summer. Animals fed the Drylot 1 ration from the end of September to May 15th were ready for pasture at 295 kg, which is the same weight as for the summer trials. Thus, these trials represented a type of retained ownership through the winter, versus buying calves in the spring.

The fall trials for the Watrous and Aylsham locations were used to examine the economics of finishing cattle on pasture. In these trials, calves were purchased at 204 kg on September 30th and fed in a drylot until May 15th. They grazed the four paddocks the same as in the summer trials, but received barley supplement at a rate of 4 or 5 kg/head/day and were sold on September 30th as finished animals.

There were several additional fall trials done at the Swift Current location because of the potential to fall graze. The fall grazing trials analyzed included grazing the calves on two paddocks of RWR during the fall before putting them into drylot for the winter. In these trials, the calves were bought at 204 kg on September 30th and grazed until November 30th. The calves are then put into drylot until May 15th after

which they were put onto the CWG paddocks until July 30th or August 10th, depending on whether the cattle were being finished.

The fall grazing trials at Swift Current also included with and without the addition of supplement using Drylot 1 and Drylot 2 winter rations, and again grazing in the summer with or without supplement.

4.5 Price Risk

One focus of this project was to analyze the risk efficiency of several backgrounding and some finishing systems that utilize grazing, with emphasis on the production differences between systems. To compare the risk/return trade-off of the trials, production results from the GrassGro model were used. Feeder purchase and selling price are also critical to the economic returns. Using realistic and accurate prices that reflect actual market situations is an important part of the analysis. To analyze the risk/return trade-off of the different production systems, prices in the model were based on the year 2000 price levels. Using the 2000 prices makes the analysis more realistic for current market conditions compared to using historical data parameters, because historical parameters do not capture the fact that the current cattle price cycle is at, or near a peak. To include price variability in the model, because the selling price is not known at purchase time, historical data were used to establish how margins changed between the purchase and selling prices for given animal weight classes throughout the cattle cycle. Further analysis to build a distribution of gross returns included a price analysis where the margin between the buying and selling prices was varied. By considering past data through several cattle cycles, it was possible to determine how the price margin changes from spring to fall between the buying and selling weight classes. In each scenario, the cattle were purchased at the same time and price. This makes the

risk of the different backgrounding systems dependant solely on weight gain and selling price. The price change was captured in the margins, and used for any point in the cattle cycle.

Figure 4.1 shows price margin changes for calves bought at 295 kg and sold at 363 kg. It shows that, typically, the price margin is negative because the price/kg of calves drops as calves get heavier, but the amount of the price change from buying time changes differently for each time period.

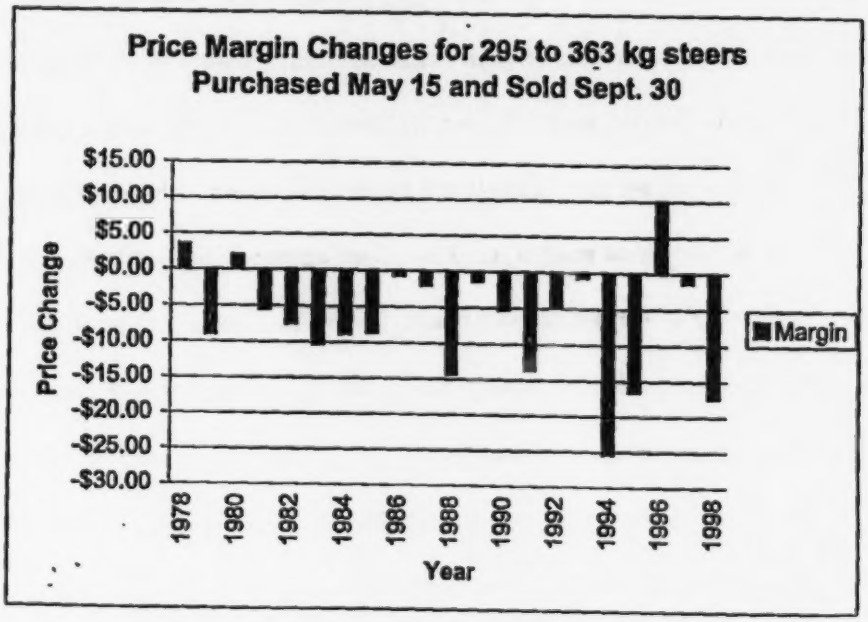

Figure 4. 1 Price Margins Between 295 kg and 363 kg Steers

The price data used reflected central Alberta weekly steer prices for each weight category going up in 45 kilogram intervals from small calves to slaughter weight (Canfax, 2000). The Saskatchewan and Alberta feeder prices were assumed to follow the same trend, thus, the Alberta margins were applied in this analysis. The first step was to detrend the prices to 2000 dollars. This was done using the LINEST function in

Excel which returns an array describing a straight line that best fits the data calculated by using the least squares method. Once the array was estimated, historical prices were adjusted to reflect any year's prices.

The price data are in 45 kg intervals, but in the analysis calves were sold at many different weights. To try and make prices more precise, prices were adjusted around these weight ranges. For example, if a calf is sold at a weight of 386 kg, the price used was the average of 363 kg and 408 kg. The calf prices were divided into intervals, such that calves being sold at a weight between 351.5 kg and 374 kg were sold at the price quoted for 363 kg steers. Steers that weighed from 374 to 397 kg were sold at the average price between 363 and 408 kg. This was done around every 45 kg price interval.

4.5.1 Pricing Method

For summer trials, the calves were purchased on May 15th at 295 kg, at a price of $3.09/kg. This price was used for all trials. The selling price differed for the various trials because the animals were removed from the pasture at different weights. There were also several price possibilities for each weight class because the price change between the buying and selling prices varied with weight class.

The margins were estimated by calculating the percentage change between the detrended historical buying prices for 295 kg calves each year, and the corresponding detrended historical selling price for the calves of the appropriate weight range. This percentage change was used to adjust the year 2000 buying price in the model ($3.09/kg for summer trials) to compute a selling price. This means, taking the actual buying price ($3.09/kg), and multiplying it by the calculated percentage change to calculate the

selling price. These margins were calculated for the 21 years of price data available, (1978 – 1998). It was assumed that for each year of production there were 21 selling price possibilities. All of these combinations (21 years production * 21 pricing possibilities each year) were used to develop a distribution of gross returns based on 441 observations. This methodology worked very well for summer trials because once the purchase price was adjusted for the margins, the distribution of selling price had an average price very close to the actual selling prices for the fall of 2000.

This pricing methodology when applied to the fall trials where animals were sold as finished animals at the end of the following summer was not quite as accurate. This was because of the extremely high price of calves in the fall. Taking the percentage change of margins off this high price did not bring the buying price in line with actual prices. The risk was still well incorporated, but the prices had to be reduced by a constant amount to keep the selling price in line with year 2000 market prices and permit an accurate comparison between the fall and spring trials.

The price and production simulations results were combined to create a distribution of gross revenue. In many other studies involving cattle feeding, production is often assumed to be fixed, while the cost of inputs and/or output prices are the main determinants of income variability. In this analysis, production was considered to be a large part of income variability.

In this analysis, price risk was included by centering prices around current prices. To keep the net revenue calculations current, and for the year 2000, only one input budget was developed using cash costs from the year 2000 for variable costs, and annualized costs for fixed costs.

4.6 Budgets

The analysis assumes that a producer wants to include cattle in the operation, and will either feed the cattle on pasture, or in a drylot. This decision has to be made at least one year ahead of time to convert the land to pasture, because grass needs to be seeded, fences built, and a water system put in place. Once the pasture is ready, the producer has to decide on the method of utilization. It was assumed that producers were certain of the costs for all trials and how the cost structures differed between trials when deciding which alternative to use to feed their calves. The risks these producers face arises from the production risk of these different trials and the different selling prices they receive.

The budgets for the various trials were straight forward because only a one year time-frame had to be developed for each trial. The purchase price of the calves for the summer trials was $3.09/kg for 295 kg calves, and for the fall trials, the calves were bought at 204 kgs at a price of $3.75/kg. Death loss for the summer trials was assumed to be zero, while in the fall trials it was set at 2% (Cohen, 2000). Animals were assumed to die at the end of the drylot period. All other variable costs such as feed, veterinary costs, fuel, utilities and fertilizer were developed using information from personal contacts in the respective industries, and are shown in Appendix B. Nitrogen fertilizer was used at all locations at a rate of 50 kg/ha in Swift Current and Watrous, and 100 kg/ha in Aylsham.

To compare grazing trials with drylot trials, the cost of drylotting calves was required. First it was assumed that these producers were not interested in a large drylot operation and did not want to keep animals on the farm throughout the winter. To take advantage of economies of size and to eliminate the need to build extensive wintering facilities, budgets were calculated on the basis that whenever animals needed to be in a

drylot, they would be custom fed by a large feeding operation. Feed requirements were estimated by GrassGro, and vet costs were calculated based on industry numbers (Large Animal Vet Clinic, 2000), but a fixed cost for yardage was required to pay the custom feeder. These yardage costs were different depending on the ration being fed to the calves. Calves on the Drylot 1 ration had a yardage cost of $0.38/head/day and calves being finished or on Drylot 2 had a yardage cost of $0.35/head/day (Pogu, 2000). Yardage cost is the fixed cost of keeping the cattle, while feed and veterinary costs are additional expenses that must be paid by the owner of the cattle. These yardage costs are different because some of the profit margin made by the feedlot is by marketing feed, and calves on a growing ration require less feed and decrease the amount of feed the feedlot can market, compared to feeding a finishing ration. Also, depending if the feedlot is running at capacity, the cost per kilogram of gain is higher with a low gaining ration because the fixed costs are the same for calves on a finishing or growing ration.

In the first analysis, which was based solely on economic profit, all economic costs were included, including labour and management, opportunity cost of land and capital, and all required startup costs. Once all these and other fixed and variable costs were subtracted from gross return, the remainder is profit from the investment. This analysis assumed that the operator was in a grain operation and owned the equipment and land in this operation, and wanted to expand by one section of land, to use for grazing feeder calves. To do this, a few facilities were required: a fence to divide the section into four paddocks, a central watering system had to be developed as well as a feed grinder and feed bunks in trials where cattle were supplemented. There was also a grass establishment cost that was included in the budgets.

To calculate the annual costs of the large one-time investments (e.g. fence, water system, and feed grinder) the costs were annualized using a discount rate of eight percent (Brown, 2000). Since it was assumed that the operator was a grain producer, only variable costs for the tractor were included in the budget. The cost of the land was entered in the budget as the cash rent which the producer could have received or had to pay for the given quality of land in the area. In the more northern locations it was assumed the land was more productive because of soil quality and precipitation. Therefore, there was a higher cost to convert the land to pasture as the producer could have rented the land out at a higher price (Gerwing, 2000).

The pasture grasses (CWG and RWR) were assumed to be established with a nurse crop, which was harvested as a normal grain crop. Also, if the pasture is properly managed, it does not need to be reseeded. Therefore, the only cost of grass establishment included in the budget was the annualized cost of the investment in seed.

4.7 Grain Production Comparison

To compare results of the grazing trials, economic returns of a representative crop rotation were made for each area to see if producers had incentive to switch land to a grazing system. For Swift Current, a rotation of 35% wheat on summerfallow, 15% durum, 15% lentils and 35% summerfallow was used. In Watrous, a rotation of 10% wheat on summerfallow, 20% wheat on stubble, 18% barley, 13% canola on summerfallow, 16% lentils and 23% summerfallow was used. In Aylsham, a rotation of 25% wheat, 24% barley, 9% canola on stubble, 11% canola on summerfallow, 20% peas and 11% summerfallow was used.

Year 2000 Saskatchewan Agriculture and Food crop budgets were used, assuming operators were using direct seeding practices. Land costs were kept the same as the

ones used in the pasture budgets, and labour and management were calculated using a $9/hour hourly wage for field work, plus 1.21 hrs/ha for overhead time (Brown, 1998).

4.8 Distribution of Net Returns

Once the distribution of gross returns had been made, and the budgets developed for each trial, distributions of economic profit were calculated based on the 441 possible results for each summer trial (21 years of production x 21 price levels).

The mean and standard deviation for each trial was calculated in Excel and used in the MSD analysis. The MSD and stochastic dominance analyses were conducted for the trials at each location. There was no analysis conducted among locations because the purpose of this analysis was to find optimal feeding systems for producers in different soil-climatic areas.

4.9 Return On Investment Analysis

All trials were compared using the distribution of their Return on Investment (ROI). In the drylot and grazing trials, the investment is in the cattle, and thus the ROI distribution was calculated by dividing the total profit of the trial by the purchase cost of all the cattle bought for the trial.

4.10 Stochastic Dominance Analysis

Identification of the risk efficient production options was completed using the RISKROOT program. This program starts by using FSD and SSD criteria to compare the distribution of net returns for each production option. If further discrimination power is required, RISKROOT will compute risk aversion coefficients (RAC) to differentiate among the risky prospects under the assumption of constant risk aversion. This method does not require an RAC to be specified, but is determined by the program (McCarl, 1988).

It was assumed that decision makers are risk averse. A moderately risk averse individual's RAC was assumed to lie between 0.00004 and 0.0005, and a very risk averse individual's RAC to lie between 0.00051 and 0.001 (Schoney, 1996). The overall dominant alternative was determined when the RAC for the moderately risk averse fell within the above range.

Stochastic dominance was used for the grazing trials, but not for drylot trials because the methodology led to a very narrow distribution of net returns for the latter trials. This happened because in the drylot, production was fixed or independent of weather, which left only the price variability to define the probability distribution. Therefore, the grazing trials used stochastic dominance to determine the most risk efficient option, and these were compared to the drylot trials using the MSD framework.

4.11 Cash Analysis

Although the concept of economic profit is an important criteria for comparing the returns from backgrounding cattle versus other opportunities, producers often do not consider all the alternatives. Most producers want to remain in agricultural production because of personal preferences. Also, some producers may have facilities to background cattle which are not being used, and meanwhile they are still incurring the fixed cost of owning these assets.

To consider these types of producers, further analysis of the trials was done on a cash flow basis. This assumes producers already have a section of land with a reasonable fence and water source. Cash flow analysis may be considered because in the current situation producers may presently be cropping land, and in many cropping situations, producers may be barely covering variable costs. Therefore, these producers may be better to switch to grazing cattle rather than remain growing annual crops

4.11.1 Methodology of Cash Trial

The cash flow analysis was done only for the grazing trials. The methodology was as described previously, except that in the budgets, the labour and management and fixed costs were removed. Thus the returns represented the margins above variable costs.

Chapter 5 Results

5.1 Introduction

This chapter presents the results of the economic analysis to determine the most risk efficient way to diversify a grain farm into the cattle feeding industry. There were two main alternatives, to purchase cattle and have them custom fed, or background or finish the animals on pasture. The main focus was on backgrounding cattle on pasture versus in a drylot, but some additional analysis was done to examine the economic merits of finishing cattle in a pasture environment. The analysis used stochastic dominance to compare the risk efficiency of the grazing systems at each of the three locations. The MSD approach was used to compare the performance of the grazing to the drylot options.

5.2 Production Results

The number of calves that were grazed increased when fertilizer was applied to the pasture, but there was also a significant increase when energy supplement was given throughout the grazing season. Also, in the more northern locations, higher carrying capacity was achieved on the pasture because of increased moisture in the areas studied. Table 5.1 shows the stocking rates for the various trials studied. In each location, trials were run for 21 years. In each trial, virtually every year the calves were sold at a different weight. These weights are shown in Table 5.2 and Table 5.3.

Table 5.1 Average Stocking Rates of Trials

Swift Current			Watrous		Aylsham
Trial	Stocking Rate		Trial	Stocking Rate	Stocking Rate
Trial 1	2.4		Trial 1	2.9	4.2
Trial 2	2.1		Trial 2	2.7	4.5
Trial 3	0.4		Trial 3	0.7	1.6
Trial 4	5.2		Trial 4	6.1	11.5
Trial 5	5.0		Trial 5	5.6	10.8
Fall Trial	1.6		Fin 5	2.0	3.0
Fall 1S	4.0		Fin 6	4.0	6.0
FinSC	2.0				
Fin 6	3.5				

Stocking rate is in animals per hectare

The results show that production options that use supplementation decrease production risk. This is because in dry years these animals are still getting enough energy to gain weight while the animals without supplement may lose weight during parts of the grazing season. In the years with favorable growing season rainfall, calves without supplement may have additional grass to eat because of the lower stocking rates, and this increases the standard deviation of weight gains for the low input trials.

5.3 Returns

The average economic profit and ROI for all feeding trials analyzed were negative. These results are counterintuitive given the enthusiasm that exists in the beef industry, but compared to the full economic profit of other agriculture alternatives, these returns are higher than most other production alternatives.

In Table 5.4, the total cost for each grazing trial is given along with the minimum, maximum, average return, and the total number of calves involved in each trial. The more intense trials, that included supplementing the calves, (Trial 4 and 5)

Table 5.2 Selling Weights of Calves for Aylsham and Watrous Trials

	Aylsham end of summer weights (kg)					Watrous end of summer weights (kg)				
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5
Sept. 78	386	371	399	378	376	405	390	416	384	384
Sept. 79	360	367	374	359	358	305	309	346	338	338
Sept. 80	361	360	365	356	353	328	326	341	323	321
Sept. 81	344	322	330	346	342	306	297	299	316	313
Sept. 82	380	378	377	368	367	405	404	382	386	385
Sept. 83	386	374	363	358	357	412	404	393	396	397
Sept. 84	401	400	377	386	385	298	300	315	326	324
Sept. 85	433	434	406	416	415	366	377	371	367	368
Sept. 86	303	296	345	341	340	352	350	351	357	356
Sept. 87	393	394	389	373	371	376	369	359	354	354
Sept. 88	304	308	316	331	327	307	294	297	310	308
Sept. 89	369	355	351	350	346	332	306	297	318	315
Sept. 90	343	352	374	353	351	308	302	326	335	333
Sept. 91	324	320	328	345	341	399	389	355	376	376
Sept. 92	313	307	317	330	325	386	389	390	378	379
Sept. 93	404	411	375	394	395	427	427	410	432	434
Sept. 94	388	378	390	377	377	414	413	427	416	417
Sept. 95	358	364	377	362	360	383	391	407	405	404
Sept. 96	406	410	392	390	389	385	384	388	385	386
Sept. 97	338	343	371	358	356	395	398	397	393	394
Sept. 98	329	323	341	344	343	376	377	392	392	393
Average	363	360	365	363	361	365	362	365	366	366
S.D.	36.52	37.91	26.38	21.78	22.87	42.54	44.30	40.68	35.61	36.86

Table 5.3 Selling Weights of Calves for Swift Current Trials

Swift Current end of summer weights (kgs)						Swift Current			Watrous	Aylsham
	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Fall Trial	Fall 1S	Fin 6	Fin 6	Fin 6
Sept. 78	388	373	400	362	358	353	375	543	527	553
Sept. 79	343	342	370	346	342	347	346	540	528	558
Sept. 80	359	352	347	337	334	363	365	552	513	519
Sept. 81	355	348	338	347	344	393	419	592	580	567
Sept. 82	416	417	400	412	411	377	398	578	585	553
Sept. 83	368	371	391	396	393	334	336	542	514	571
Sept. 84	317	321	343	343	340	360	338	540	569	592
Sept. 85	311	320	347	334	330	385	395	587	545	504
Sept. 86	397	393	386	378	377	363	359	572	556	563
Sept. 87	375	380	377	372	370	334	330	530	507	516
Sept. 88	311	308	303	320	315	374	372	568	514	541
Sept. 89	405	394	354	358	354	357	353	542	536	550
Sept. 90	311	314	329	329	324	379	398	556	568	522
Sept. 91	403	396	363	367	366	340	344	555	583	514
Sept. 92	354	362	353	347	344	339	351	567	580	556
Sept. 93	386	388	355	373	370	380	388	565	587	562
Sept. 94	344	346	378	381	379	360	366	580	578	563
Sept. 95	401	401	373	401	400	369	374	571	569	578
Sept. 96	368	367	378	372	370	379	396	589	578	545
Sept. 97	393	392	394	387	385	342	342	552	564	517
Sept. 98	327	332	336	340	337					
Average	363	363	363	362	359	361	367	561	554	547
S.D.	34.27	31.88	25.59	25.19	25.98	17.93	25.22	18.54	28.07	24.29

have more calves in the trial, and have significantly higher costs because of the extra cost of buying the calves.

Table 5.4 Cost and Net Returns for Trials by Location

	Total Number of animals	Total Cost $/Section	Minimum Net Return $/Section	Maximum Net Return $/Section	Average Net Return $/Section	Average Net Return $/ha
Swift Current						
Trial 1	156	$171,634	-$43,226	$54,775	-$9,478	-$36.46
Trial 2	137	$154,631	-$43,351	$43,833	-$12,040	-$46.31
Trial 3	26	$44,113	-$22,905	-$7,834	-$17,000	-$65.39
Trial 4	338	$363,149	-$77,084	$122,407	-$9,756	-$37.52
Trial 5	325	$351,019	-$79,673	$114,174	-$13,982	-$53.78
Fall Trial	104	$118,859	-$41,241	$49,732	-$13,564	-$52.17
Fall 1S	260	$270,698	-$78,916	$166,290	-$5,673	-$21.82
Fln SC	130	$152,184	-$58,851	$63,698	-$15,650	-$60.19
Fln 6	228	$257,931	-$97,863	$117,082	-$11,587	-$44.57
Watrous						
Trial 1	189	$207,171	-$56,322	$70,345	-$11,105	-$42.71
Trial 2	176	$196,796	-$57,884	$61,176	-$15,558	-$59.84
Trial 3	46	$66,876	-$30,603	$92	-$19,364	-$74.48
Trial 4	397	$425,314	-$100,067	$164,327	-$10,670	-$41.04
Trial 5	371	$400,227	$98,427	$154,156	-$13,182	-$50.70
Fln 5	130	$161,090	-$71,690	$39,743	-$25,461	-$97.93
Fln 6	260	$294,675	-$119,595	$130,031	-$16,680	-$64.15
Aylsham						
Trial 1	273	$294,464	-$72,184	$113,088	-$10,645	-$40.94
Trial 2	293	$317,067	-$84,375	$119,969	-$14,617	-$56.22
Trial 3	104	$128,924	-$41,771	$18,274	-$19,992	-$76.89
Trial 4	748	$783,872	-$143,041	$299,334	-$2,390	-$9.19
Trial 5	702	$740,445	-$135,899	$273,964	-$8,748	-$33.64
Fln 5	195	$232,028	-$101,343	$70,541	-$29,481	-$113.39
Fln 6	390	$430,956	-$169,875	$212,075	-$19,052	-$73.28

Although the returns of these feeding trials are all negative, there still may be reason for producers to start feeding cattle. The returns of traditional grain crops are very poor, and even with the introduction of new crops into rotations, economic returns are very negative. In Swift Current, the representative rotation of Wheat, Durum,

Lentils and summerfallow had a return of -$48.70/ha, which is lower then most of the grazing trials. In Watrous, the Wheat, Barley, Canola, Lentils, and summerfallow rotation had a return of -$82.84/ha which is worse than all grazing trials except for trial Fin 5. In Aylsham the Wheat, Barley, Canola, Peas and summerfallow rotation had a return of -$131.96/ha, which is much poorer than all of the grazing trials. It is these very negative returns in grain operations that lead to the incentive for producers to diversify into cattle production.

5.3.1 Retained Ownership

As discussed in the methodology, some of the fall trials were a type of retained ownership strategy. In these trials, calves were bought in the fall, fed through the winter using the Drylot 1 backgrounding ration, and then turned out to pasture at the same weight as calves purchased for the summer trials. In both trials, the calves came off the pasture in the fall at similar weights, and therefore, the only difference was in the costs. This analysis was used to determine if it was more profitable to buy calves in the fall and have them custom fed, or buy them in the spring. The economic results were very similar for these two alternatives. However, buying calves in the spring was slightly more profitable, plus there was a lower risk of death loss compared to retaining ownership through the winter. Therefore, the summer trials were dominant to the winter feeding trials in all situations, and no further analysis was done with the fall Drylot 1 trials.

5.4 Stochastic Dominance Results

Trials that included grazing were analyzed using stochastic dominance. The graphs of the CDF's for selected trials are shown for the respective locations in Figures

5.1, 5.2, and 5.3. For risk averse individuals, the CDFs which lay mostly to the right are potentially risk efficient because they have lower probabilities of producing low returns for most levels of return.

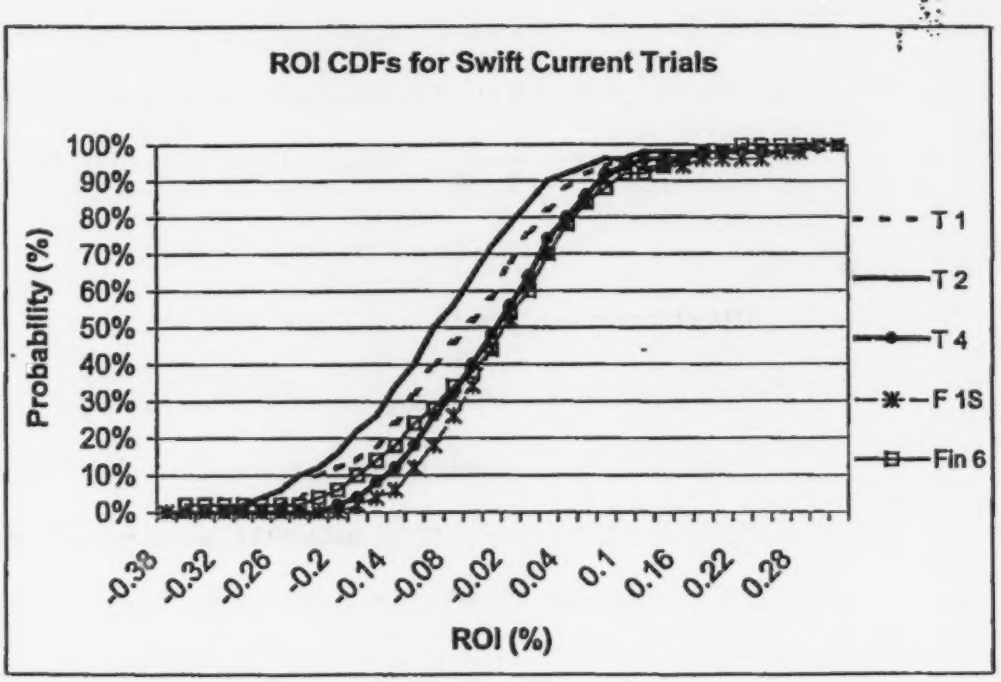

Figure 5. 1 CDF for Swift Current Grazing Trials

Trial 1: May 15 – Sept. 30, No sup., Fertilized, Sand, S.R. = 2.4 an/ha, buy calves at 295 kg, sell at 363 kg.
Trial 2: May 15 – Sept. 30, No sup., Fertilized, Loam, S.R. = 2.1 an/ha, buy calves at 295 kg, sell at 363 kg.
Trial 4: May 15 – Sept. 30, 2 kg Barley sup., Fertilized, Loam, S.R. = 5.2 an/ha, buy calves at 295 kg, sell at 362 kg.
Fall 1S: Sept. 30–July 30, Fall graze with 1 kg barley sup, drylot 1 Nov. 1 – May 14, graze until July 30, no sup, loam, Fert, S.R = 4, buy calves at 204 kg and sell at 368 kg
Fin 6: Sept. 30-Sept. 29, Drylot 2 Sept. 30 – May 15, Graze all summer, 5 kg barley sup, Fert., loam, S.R. = 3.5 an/ha, buy calves at 204 kg and sell at 561 kg.
S.R. = Stocking rate.
an/ha = Animals per hectare.

The results from the RISKROOT analysis provided a very definitive answer for the Swift Current trials (Figure 5.1). For all risk averse decision makers, or even anyone with a RAC above –19.46, Trial Fall 1S was risk efficient.

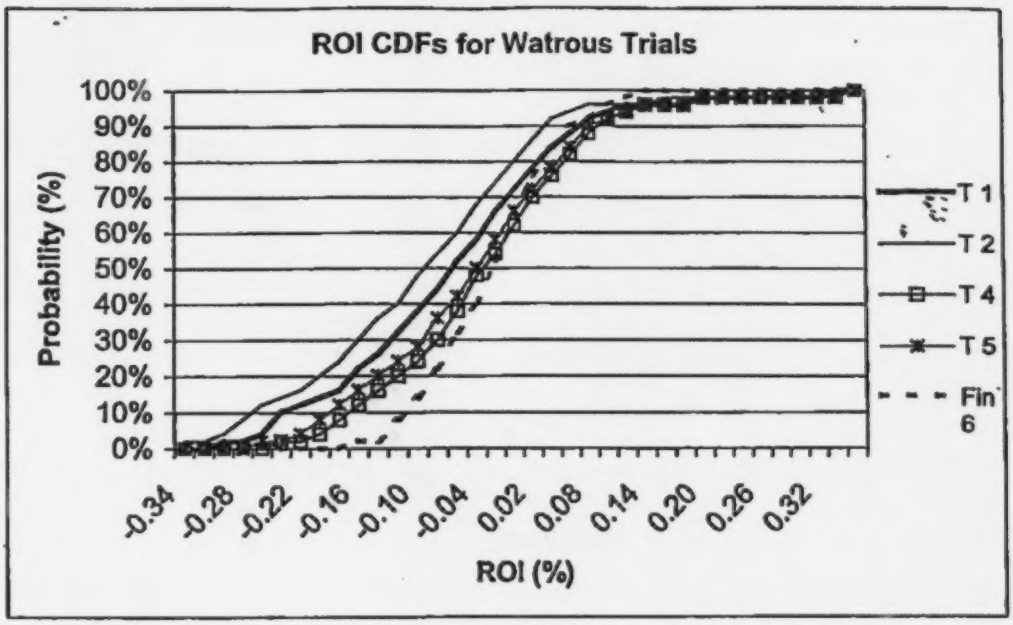

Figure 5. 2 CDF for Watrous grazing Trials

Trial 1: May 15 – Sept. 30, No sup., Fertilized, Sand, S.R. = 2.9 an/ha, buy calves at 295 kg, sell at 365 kg.
Trial 2: May 15 – Sept. 30, No sup., Fertilized, Loam, S.R. = 2.7 an/ha, buy calves at 295 kg, sell at 362 kg.
Trial 4: May 15 – Sept. 30, 2 kg Barley sup., Fertilized, Loam, S.R. = 6.1 an/ha, buy calves at 295 kg, sell at 366 kg.
Trial 5: May 15 – Sept. 30, 2 kg Barley/protein sup. Fert., Loam, S.R. = 5.7 an/ha, buy calves at 295 kg, sell at 366 kg.
Fin 6: Sept. 30-Sept. 29, Drylot 2 Sept. 30 – May 15, Graze all summer, 4 kg barley sup, Fert., loam, S.R. = 4 an/ha, buy calves at 204 kg and sell at 556 kg.

Similarly, at the Watrous site, as long as the decision maker is risk averse only one trial was risk efficient, namely Trial Fin 6 (Figure 5.2).

However, at Aylsham two trials were identified as risk efficient (Figure 5.3). For most risk averse producers (i.e. RAC between –20.14 and 9.346), they would prefer Trial 4. If an individual had extreme risk aversion, with a RAC above 9.34, they would choose Fin 6 as the preferred option.

The Fin 6 trial ranked very well in all locations. This is partly because there was much lower production risk for this trial. The animals always performed well, and came off pasture finished. They received much of their energy from the barley supplement which

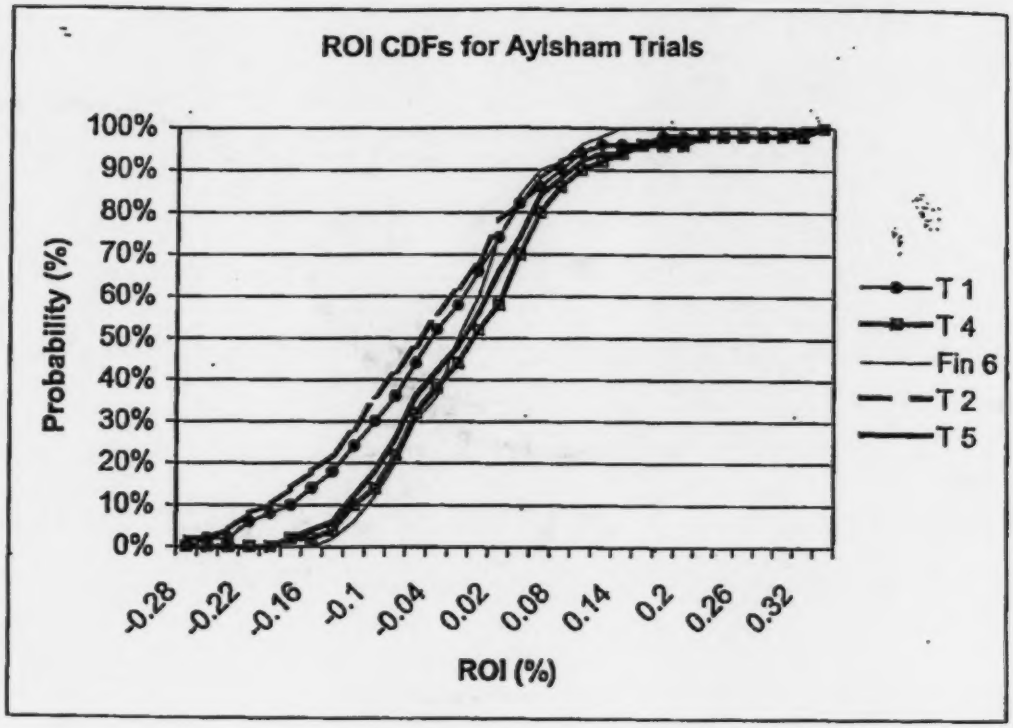

Figure 5. 3 CDF for Aylsham Grazing Trials

Trial 1: May 15 – Sept. 30, No sup., Fertilized, Sand, S.R. = 4.2 an/ha, buy calves at 295 kg, sell at 363 kg.
Trial 2: May 15 – Sept. 30, No sup., Fertilized, Loam, S.R. = 4.5 an/ha, buy calves at 295 kg, sell at 360 kg.
Trial 4: May 15 – Sept. 30, 2 kg Barley sup., Fertilized, Loam, S.R. = 11.5 an/ha, buy calves at 295 kg, sell at 363 kg.
Trial 5: May 15 – Sept.30, 2 kg Barley/protein sup., Fert, Loam, S.R = 10.8 an/ha, buy calves at 295 kg, sell at 361 kg.
Fin 6: Sept. 30-Sept. 29, Drylot 2 Sept. 30 – May 15, Graze all summer, 4 kg barley sup, Fert., loam, S.R. = 4 an/ha buy calves at 204 kg and sell at 548 kg.

maintained a high and consistent rate of gain. To compare these results with backgrounding in a drylot, the MSD framework is used in the next section.

5.5 MSD Results

The following graphs show the mean and standard deviation of ROI for the different trials at each location (Figure 5.4, 5.5, and5.6). The trials at Watrous and Aylsham had similar relative positioning of the trials.

In the analysis, it was assumed that decision makers were only slightly risk averse. These types of producers prefer less risk to more, but are not willing to forego

large amounts of expected income to decrease risk only a small amount. From the Swift Current results, Sumdry and Fall 1S would be preferred (Figure 5.4).

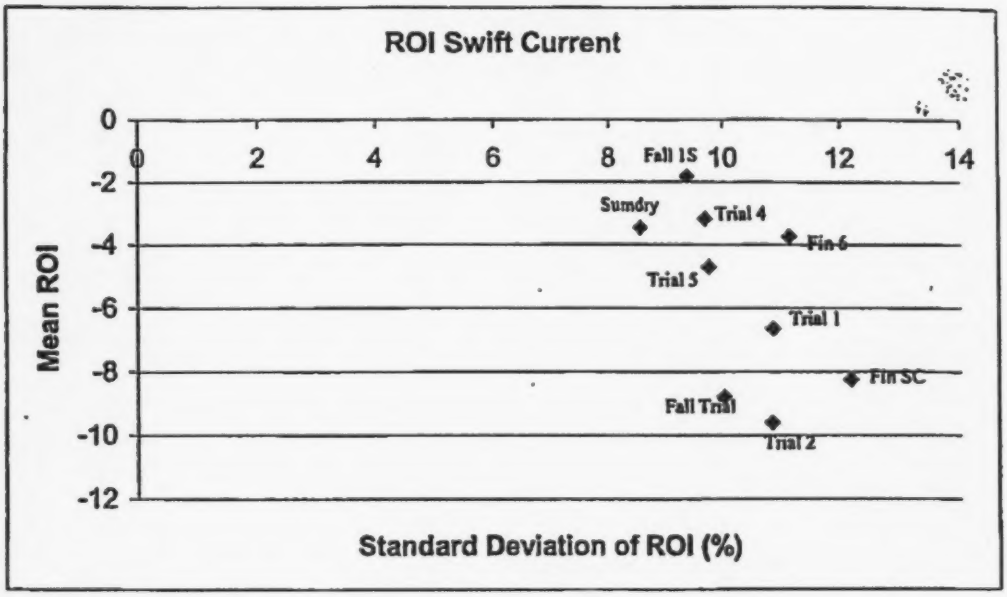

Figure 5. 4 MSD Results for Swift Current

Note: Trial 3 was omitted to improve the display of the more efficient trials. Trial 3 coordinates are (10.0, -70.9)
Trial 1: May 15 – Sept. 30, No sup., Fertilized, Sand, S.R. = 2.4 an/ha, buy calves at 295 kg, sell at 363 kg.
Trial 2: May 15 – Sept. 30, No sup., Fertilized, Loam, S.R. = 2.1 an/ha, buy calves at 295 kg, sell at 363 kg.
Trial 3: May 15 – Sept. 30, No sup., No Fertilizer, Loam, S.R. = 0.4 an/ha, buy calves at 295 kg, sell at 362 kg.
Trial 4: May 15 – Sept. 30, 2 kg Barley sup., Fertilized, Loam, S.R. = 5.2 an/ha, buy calves at 295 kg, sell at 362 kg.
Trial 5: May 15 – Sept. 30, 2 kg Barley/protein sup., Fert., Loam, S.R.= 5.0 an/ha, buy calves at 295 kg, sell at 359 kg.
SumDry: May 15 – Sept. 30 Calves fed in drylot, 20% barley and 80% hay ration, buy at 295 kg sell at 363 kg.
Fall Trial: Sept. 30–July 30, Fall graze no sup, drylot 1 Nov. 1 – May 14, graze until July 30, no sup, loam, Fert, S.R = 1.6, buy calves at 204 kg and sell at 361 kg.
Fall 1S: Sept. 30–July 30, Fall graze with 1 kg barley sup, drylot 1 Nov. 1 – May 14, graze until July 30, no sup, loam, Fert, S.R = 4, buy calves at 204 kg and sell at 368 kg.
Fin 6: Sept. 30-Sept. 29, Drylot 2 Sept. 30 – May 15, Graze all summer, 5 kg barley sup, Fert., loam, S.R. = 3.5 an/ha buy calves at 204 kg and sell at 561 kg.
FinSC: Sept. 30 – Aug. 10, fall graze 1 kg sup. Drylot 2 Dec. 1 – May 15 graze until Aug. 10, 4kg barley sup, fertilized loam soil, buy at 204 kg and sell at 536 kg.

At the Watrous site, Fin 6 would be preferred (Figure 5.5). This is the same result that was determined using the stochastic dominance analysis.

At Aylsham, Fin 6 and Trial 4 are risk efficient (Figure 5.6).

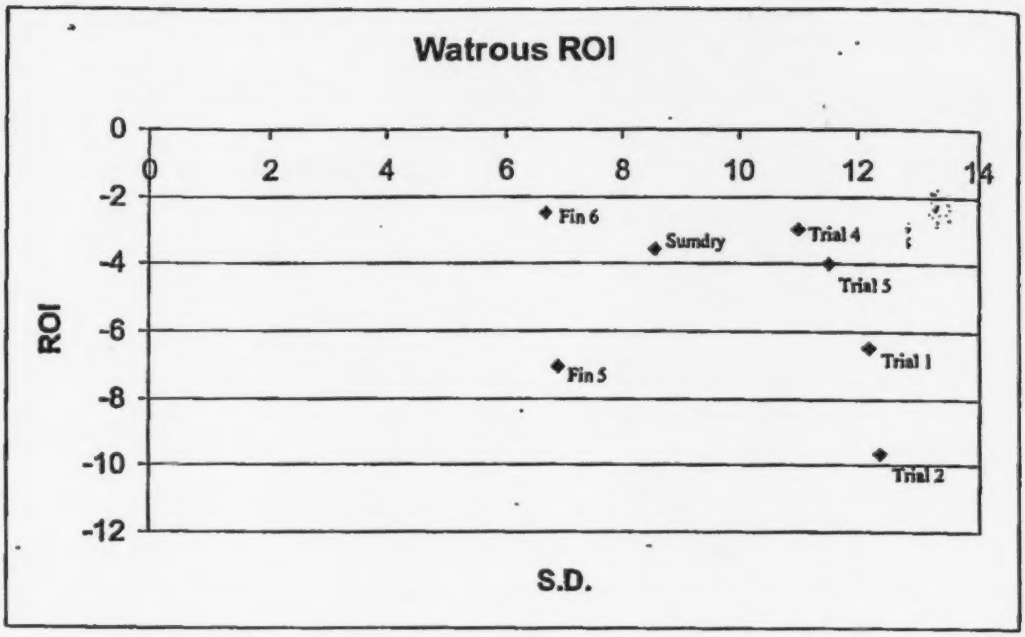

Figure 5. 5 MSD Results for Watrous

Note: Trial 3 was once again omitted from the graph. Its coordinates are (11.9, –46.2) Trials follow similar description to the descriptions given under figure 5.4.

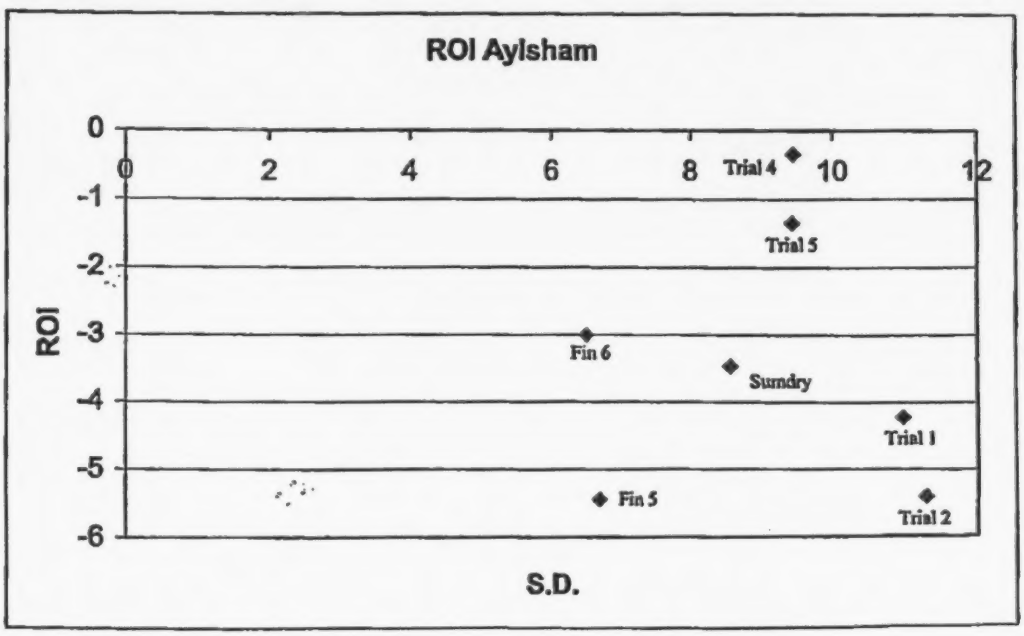

Figure 5. 6 MSD Results for Aylsham

Note: Trial 3 was once again omitted from the graph. Its coordinates are (9.9, -20.8)

5.6 Cash Analysis Results

The cash analysis was done for all trials that included grazing. The fixed costs were similar for all trials except for some small changes in the value of land for Trial 1, and the trials that included the use of supplements needed feed bunks and a grinder. This analysis did not change the ranking of the alternative trials, but may help to explain the popularity of backgrounding, especially in operations that have most of the required facilities in place (Table 5.5, 5.6, and 5.7).

Table 5.5 Swift Current cash returns

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Fin 6	Fall Trial	FinSC	Fall 1S
Return $/ha	$ 93.13	$ 90.96	$ 12.16	$172.51	$107.32	$144.84	$ 69.27	$ 92.21	$199.82
S.D.	241	209	36	465	451	709	258	395	657

At Swift Current (Table 5.5), Fall 1S provided the highest return per hectare compared to the other trials, but it also had the highest standard deviation. Several trials are in the efficient set, but Fin 6, Fall Trial and FinSC were dominated by at least one other trial.

Table 5.6 Watrous cash returns

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Fin 5	Fin 6
Return $/ha	$116.67	$87.61	$27.26	$210.09	$171.23	$ (14.37)	$123.77
S.D.	326	308	77	620	593	386	816

The cash returns for the Watrous site show different results than for the ROI analysis (Table 5.6). Trial 4, 5 and 1 appear better than Fin 6. They have about equal or higher returns with lower standard deviations. One explanation may be that with the Fin 6 trial, animals have to spend some time in a drylot being custom fed. In the feedlot's cost, part of the costs are fixed costs, but since the animals are being custom fed all the costs of the feedlot to the owners of these animals are cash costs, and are being

subtracted from the returns of these trials. Therefore, it makes the cash returns of these trials lower. As can be seen, there are some difficulties in comparing some of these trials using cash flow, and economic profitability is the better measure for long term analysis.

Table 5.7 Aylsham cash returns

	Trial 1	Trial 2	Trial 3	Trial 4	Trial 5	Fin 5	Fin 6
Return $/ha	$ 172.42	$ 160.07	$ 76.19	$ 407.54	$ 310.61	$ (15.59)	$ 144.28
S.D.	427	469	147	1002	939	577	1199

In the Aylsham trials (Table 5.7), using the ROI analysis, trial 4 was dominant. In the cash flow analysis, it has a very high return but also a high standard deviation. Fin 5, Fin 6 and Trial 2 are not risk efficient and are dominated by at least one other trial, under the MSD framework.

5.7 Summary

Chapter 5 provides the results of an analysis of several cattle feeding options for three locations across Saskatchewan.

In Watrous, the risk efficient trial was the finishing trial (Fin 6), while in Aylsham it would only dominate for extremely risk averse individuals. In Aylsham, the dominant trial was Trial 4, which is a summer trial that used all the inputs such as fertilizer and energy supplement. In Swift Current, the dominant trial was a fall grazing trial (Fall 1S) that consisted of grazing the calves in the fall while being fed supplement, feeding them a light backgrounding ration over winter and grazing them the following summer. This trial was dominant for both risk neutral and risk averse individuals. These results show that although it requires a higher investment when using fertilizer and energy supplement, it is a risk efficient way to feed calves.

Some analysis was done to consider producers interested in investing in beef to diversify their operation, and have calves custom fed. In Swift Current, possibly because of the lower productivity of the pasture, it showed that for risk averse individuals, it may be most efficient to own cattle and have them custom fed.

Chapter 6 Summary and Conclusions

6.1 Summary

The objective of this study was to identify risk efficient grazing systems for feeding calves in Saskatchewan. The analysis used the GrassGro model to simulate animal performance on pasture and in a feedlot. Similar grazing trials were run in three areas of Saskatchewan, Swift Current, Watrous, and Aylsham. Current prices and budgets were used, and by varying output prices and taking production variability from the GrassGro model, a distribution of returns were calculated and compared using stochastic dominance and MSD analysis. The results showed that finishing calves on grass with supplement can be competitive, especially in areas with greater pasture productivity. In the different locations, it was seen that trials including more inputs such as fertilizer and supplement were often most efficient.

6.2 Conclusions

The analysis showed that depending on the area in Saskatchewan, different feeding and grazing trials were risk efficient. In most cases, the trials on better quality soil combined with the addition of supplement were among the best. In trials with supplement and fertilizer, stocking rates could be increased substantially and many more animals could be fed on the pasture.

The fall trials were competitive with the summer trials, assuming individuals were moderately risk averse. In the economic analysis, the ROI for all trials were negative, but this has been common in recent years for agricultural enterprises to have very low or negative profits. For farmers trying to diversify their farming operation, it is

most likely the case that the economic profit of their grain enterprises are negative as well, and losses per hectare are higher than some of these cattle feeding alternatives.

In operations that had cattle previously, and have a fence and watering system in place may be able to increase cash flows of their operation by backgrounding calves through the use of a pasture grazing system. Again, it was the trials which used higher levels of inputs that produced the best potential returns for operators.

6.3 Limitations

The methodology of this thesis uses production and output price as the sources of risk in the model. The model's budget is based only on the year 2000 costs of production. The price of feed is an important part in determining the viability of feeding cattle, especially for cattle being fed in a drylot. Not having the long-term cost relationships for inputs could affect the risk efficiency ranking of the trials.

In trials that included the use of supplement, there could be a slight decrease in productivity of the pasture area around the feeding area. The area around the feeding bunks in the pasture could possibly have no productivity because of the intense cattle traffic in these areas. There is also the path in and out of the pasture where there is decreased pasture performance. These factors are not incorporated into the model, and these effects decrease the overall productivity of the pasture. To account for these losses, a slight decrease in stocking rate may be required to maintain the cattle performance data generated by the GrassGro model.

In a situation where a producer wants to diversify his/her operation into a new enterprise, a lot of new or additional knowledge is required. The model compares the returns of producing calves on pasture under the operator's supervision, versus having calves custom fed. There is a lot less knowledge and learning required to have animals

custom fed. There could be several management problems in the first few years for producers who have little or no experience managing cattle and pastures. They are more likely to witness increased deathloss, reduced performance from improperly spotting and treating sick animals, and reduced pasture productivity because of improper stocking rates. This could change the outcome of the trials. First of all, there is a definite difference in human capital between the drylot trials and the grazing trials, but there could also be a change in returns between the low intensity and high intensity trials. The intense trials require knowledge about feeding and checking large groups of animals, while the less intense operations are more simple because they only have a small group of calves self sufficient on grass. These learning curves were not included in the analysis.

6.4 Need for Further Research

To do a complete analysis of the risk efficiency of diversifying into cattle, the profitability of the current farm operation has to be known, and be compared on the same basis to determine if it is more risk efficient to expand into cattle feeding or maintain or increase resources in other current enterprises. This analysis only considered the profitability and risk efficiency of diversifying into feeding cattle. There are many other areas of diversification, and these need to be analyzed to determine if there are more effective ways to increase farm income.

At each location, the grazing systems and grass species were the same. There are many different types of grass species that can be used to pasture cattle, and they directly influence cattle performance. Studying the effects of using different grass species along with different grazing systems would be beneficial to the analysis.

Further research could also be done to look more in depth at the ownership and grazing of different weight cattle. Analysis could be done on whether or not it is more efficient to graze smaller or larger calves, and what time of year it is best to buy and sell calves to increase profitability.

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Appendix A Steer Selling Prices

A.1 Selling Price of Steers: All Trials

	Summer Trials			
Calves sold on September 30th for a selling Price of:				
675-725	726-775	776-825	826-875	876-925
$ 145.49	$ 141.83	$ 138.94	$ 136.05	$ 131.54
$ 134.94	$ 128.53	$ 126.97	$ 125.41	$ 120.06
$ 142.58	$ 142.37	$ 138.02	$ 133.66	$ 129.18
$ 130.47	$ 130.89	$ 128.49	$ 126.09	$ 122.62
$ 128.79	$ 128.15	$ 126.29	$ 124.43	$ 119.27
$ 127.41	$ 126.47	$ 122.98	$ 119.49	$ 116.65
$ 128.41	$ 127.57	$ 125.30	$ 123.03	$ 121.22
$ 129.00	$ 128.77	$ 126.36	$ 123.95	$ 120.46
$ 143.42	$ 141.84	$ 136.68	$ 131.51	$ 128.98
$ 143.69	$ 142.26	$ 136.34	$ 130.42	$ 125.20
$ 130.15	$ 126.22	$ 122.31	$ 118.39	$ 115.39
$ 143.13	$ 142.30	$ 137.07	$ 131.85	$ 125.41
$ 139.81	$ 137.47	$ 132.83	$ 128.20	$ 123.79
$ 129.68	$ 126.48	$ 123.82	$ 121.17	$ 116.57
$ 140.46	$ 138.06	$ 133.82	$ 129.58	$ 124.53
$ 146.80	$ 145.03	$ 139.64	$ 134.25	$ 129.36
$ 120.11	$ 117.88	$ 114.49	$ 111.10	$ 107.23
$ 121.69	$ 121.42	$ 120.02	$ 118.62	$ 116.27
$ 158.39	$ 158.68	$ 159.34	$ 159.99	$ 158.12
$ 146.59	$ 142.21	$ 139.88	$ 137.55	$ 131.87
$ 126.88	$ 124.26	$ 121.26	$ 118.25	$ 113.87

July 31 Selling Price Swift Current Fall Trials					Finished	Finished
675-725	726-775	776-825	826-875	876-925	10-Aug	Sept30th
N/A	$ 140.28	$ 137.08	$ 133.87	$ 122.69	$ 89.42	$ 90.83
N/A	$ 103.35	$ 101.42	$ 99.50	$ 105.65	$ 71.29	$ 68.59
N/A	$ 126.26	$ 123.29	$ 120.31	$ 117.41	$ 91.90	$ 84.63
N/A	$ 154.51	$ 151.11	$ 147.72	$ 136.43	$ 109.08	$ 101.86
N/A	$ 145.34	$ 140.36	$ 135.39	$ 126.75	$ 103.36	$ 97.56
N/A	$ 135.49	$ 133.87	$ 132.26	$ 127.59	$ 99.95	$ 93.06
N/A	$ 136.88	$ 132.48	$ 128.07	$ 122.80	$ 89.94	$ 101.10
N/A	$ 152.32	$ 146.08	$ 139.84	$ 135.65	$ 102.57	$ 106.26
N/A	$ 122.47	$ 118.68	$ 114.88	$ 111.41	$ 91.60	$ 92.87
N/A	$ 117.44	$ 114.56	$ 111.69	$ 99.09	$ 64.81	$ 68.08
N/A	$ 126.90	$ 123.67	$ 120.45	$ 110.63	$ 84.66	$ 81.45
N/A	$ 124.03	$ 122.09	$ 120.14	$ 112.17	$ 82.98	$ 84.45
N/A	$ 136.63	$ 132.73	$ 128.83	$ 122.52	$ 76.09	$ 75.78
N/A	$ 129.13	$ 125.14	$ 121.15	$ 115.62	$ 85.72	$ 88.74
N/A	$ 151.17	$ 146.87	$ 142.58	$ 136.08	$ 101.52	$ 96.68
N/A	$ 112.23	$ 109.07	$ 105.90	$ 101.90	$ 69.13	$ 61.50
N/A	$ 109.34	$ 105.13	$ 100.93	$ 97.08	$ 74.93	$ 73.37
N/A	$ 123.44	$ 123.44	$ 123.45	$ 121.55	$ 107.86	$ 114.64
N/A	$ 199.01	$ 194.96	$ 190.91	$ 185.73	$ 138.99	$ 128.90
N/A	$ 116.63	$ 113.46	$ 110.30	$ 106.25	$ 79.20	$ 76.51

Source: Author's Calculations Using Canfax Data

Appendix B Budgets

B.1 Labour Assumptions

Labour	Hours
Applying Fertilizer/year	24
Fixing Fence/year	24
Bookwork/year	10
Marketing time/year	10
Grinding feed/ supplementing day	0.333
Feeding and checking/ supplementing day	1.25
Time per non supplementing day	0.5
Time on grinder for grinding and unloading	0.5
Time on tractor hrs/day	1

Source: Author's Calculations

B.2 Watering System Costs

	Watering System			
			Discount	Present
Year	Cash flows		Factor	Value
0	solar pump, dugout & Trough	$ 17,000.00	1.000	$17,000.00
1			0.926	$ -
2	Batteries	$ 200.00	0.857	$ 171.47
3			0.794	$ -
4	Batteries	$ 210.00	0.735	$ 154.36
5			0.681	$ -
6	Batteries	$ 220.00	0.630	$ 138.64
7			0.583	$ -
8	Batteries	$ 230.00	0.540	$ 124.26
9			0.500	$ -
10	Batteries	$ 240.00	0.463	$ 111.17
11			0.429	$ -
12	Batteries	$ 250.00	0.397	$ 99.28
13			0.368	$ -
14	Batteries	$ 260.00	0.340	$ 88.52
15			0.315	$ -
16	Batteries	$ 270.00	0.292	$ 78.81
17			0.270	$ -
18	Batteries	$ 280.00	0.250	$ 70.07
19	Panels and pump	$ 5,000.00	0.232	$ 1,158.56
20	Batteries	$ 290.00	0.215	$ 62.22
21			0.199	$ -
22	Batteries	$ 300.00	0.184	$ 55.18
23			0.170	$ -
24	Batteries	$ 310.00	0.158	$ 48.89
25			0.146	$ -
26	Batteries	$ 320.00	0.135	$ 43.26
27			0.125	$ -
28	Batteries	$ 330.00	0.116	$ 38.25
29		$ -	0.107	$ -
30	Present Value Cost			$19,442.93
	Annualized Cost			$ 1,727.07

Source: PFRA

B.3 Fence and Facilities Cost

Fence and Corral		Portable feed bunks	
Annual Fence Repair	$ 300.00	Lifetime (years)	25
		Head per feed bunk	20
Miles of Fence	6	Cost per feed bunk	335
Cost per mile	$ 2,939.75	Feed bunks required	5
		Total Cost	$ 1707.16
Total fence Cost	$17,638.50	Annualized costs	$ 159.92
Corrals and shute	$ 5,000.00	Life of Corrals	20
Cost	$22,638.50		
Annualized Cost	$ 2,305.78		

Source: SAF and Author's calculations

B.4 Summer Budget

Values correspond to Watrous Trial 4

Stocking rate	6.1	
# of hectares	65	
Total # of head	396.5	
Feeders Initial weight	650	
Price per pound	1.42	
Total # of days in Trial	138	
Total # of Days on supplement	121	
Wage $/hour	9	
Price of Barley $/tonne	80	
Amount of Barley fed kgs/head/day	2	
Price of Canola meal $/tonne	176	
Amount of Canola meal fed kgs/head/day	0	
Discount Rate	8%	
Variable Costs		Total
Feed		Cost
Barley Cost/head	$ 9.68	$ 3,838.12
Canola meal cost/head	$ -	$ -
Feeder Cost	$ 923.00	$365,969.50
Vaccinations	$ 2.50	$ 991.25
Other vet Costs	$ 2.00	$ 793.00
Vitamin/mineral per head per year	$ 1.80	$ 713.70
Fuel	$ 3.39	$ 1,345.58
Utilities/office	$ 0.20	$ 79.30
Buying/Selling costs	$ 30.00	$ 11,895.00
Transportation Costs	$ 4.10	$ 1,625.65
Fence Repair	$ 0.76	$ 300.00
Fertilizer		
Amount applied (kg/ha)	45	
Cost per kg	$ 0.66	
Application cost for the section	$ 338.64	
Fert cost per head	$ 0.89	$ 353.64
Labour	$ 5.97	$ 2,367.39
Interest Rate	9%	
Interest on loan for calves/head	$ 31.41	$ 12,452.99
Fixed Costs		
Fence and Corrals	$ 5.82	$ 2,305.78
Water System	$ 4.36	$ 1,727.07
Grass Establishment	$ 2.02	$ 800.00
Cost of Land	$ 38.74	$ 15,360.00
Grinding Feed Costs not including fuel	$ 4.47	$ 1,773.76
Annualized Cost of Bunk per head	$ 1.57	$ 622.16
Total Cost	$1,072.67	$425,313.88

Sources: Manitoba Ag. and Food, Large Animal Clinic, SAF

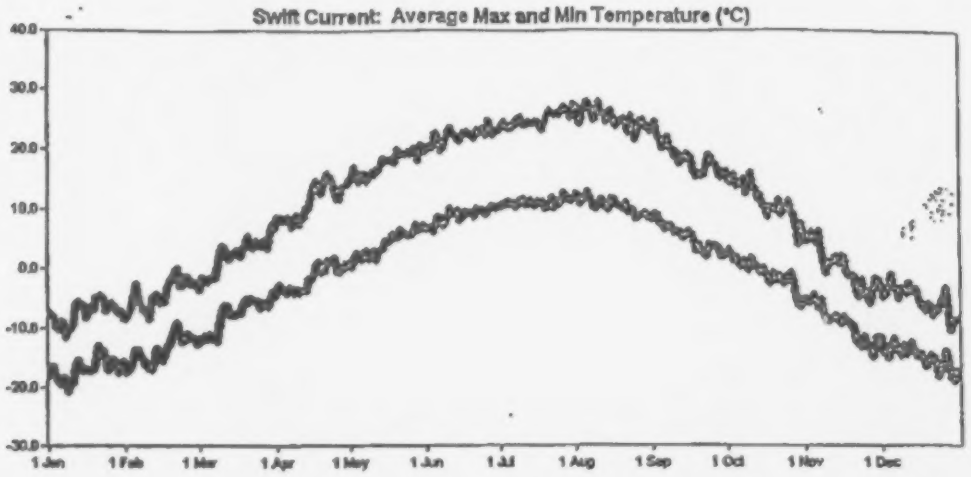
B.5 Fall Budget

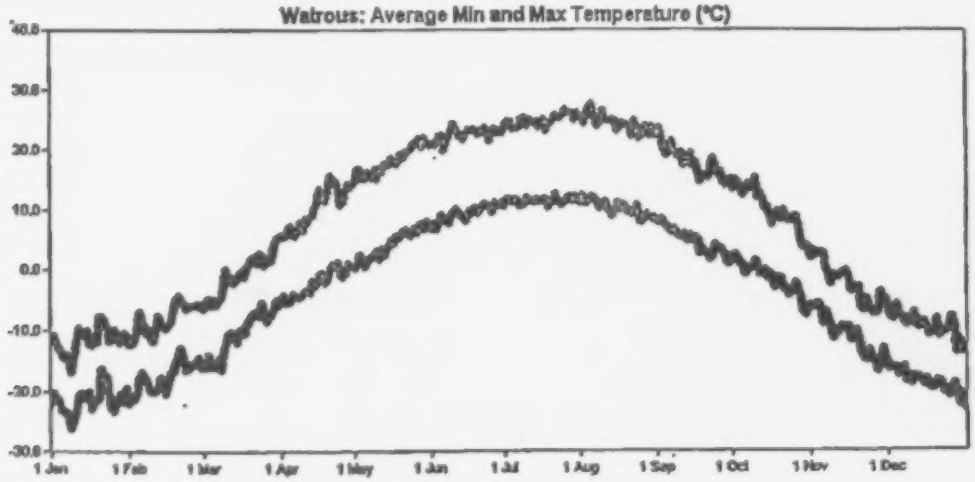
Example of Swift Current Trial Fall 1S

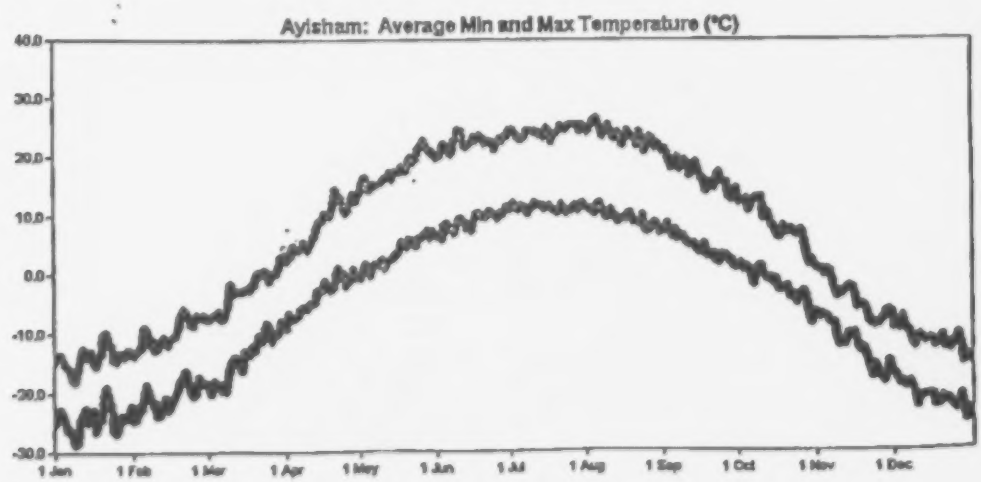
Stocking rate	4
# of hectares	65
Total # of head	260
Feeders Initial weight	450
Price per pound	1.7
Death Loss	2%
# of calves to go on pasture and be sold	254.8
# of Days	
Total Fall grazing days	61
Total Fall Supplemented days	61
Total # of days of summer grazing	77
Total # of Days on Summer supplement	0
Total # of days in drylot	166
Fall Grazing feeding	
Barley kgs/head/day	1
Drylot Feeding kgs/head	4.58
Hay kgs/head/day	3.664
Barley Kgs/head/day	0.916
Wage $/hour	9
Summer Pasture Feeding	
Price of Barley $/tonne	80
Amount of Barley fed kgs/head/day	1
Price of Hay per tonne	60
Price of Canola meal $/tonne	176
Amount of Canola meal fed kgs/head/day	0
Discount Rate	8%

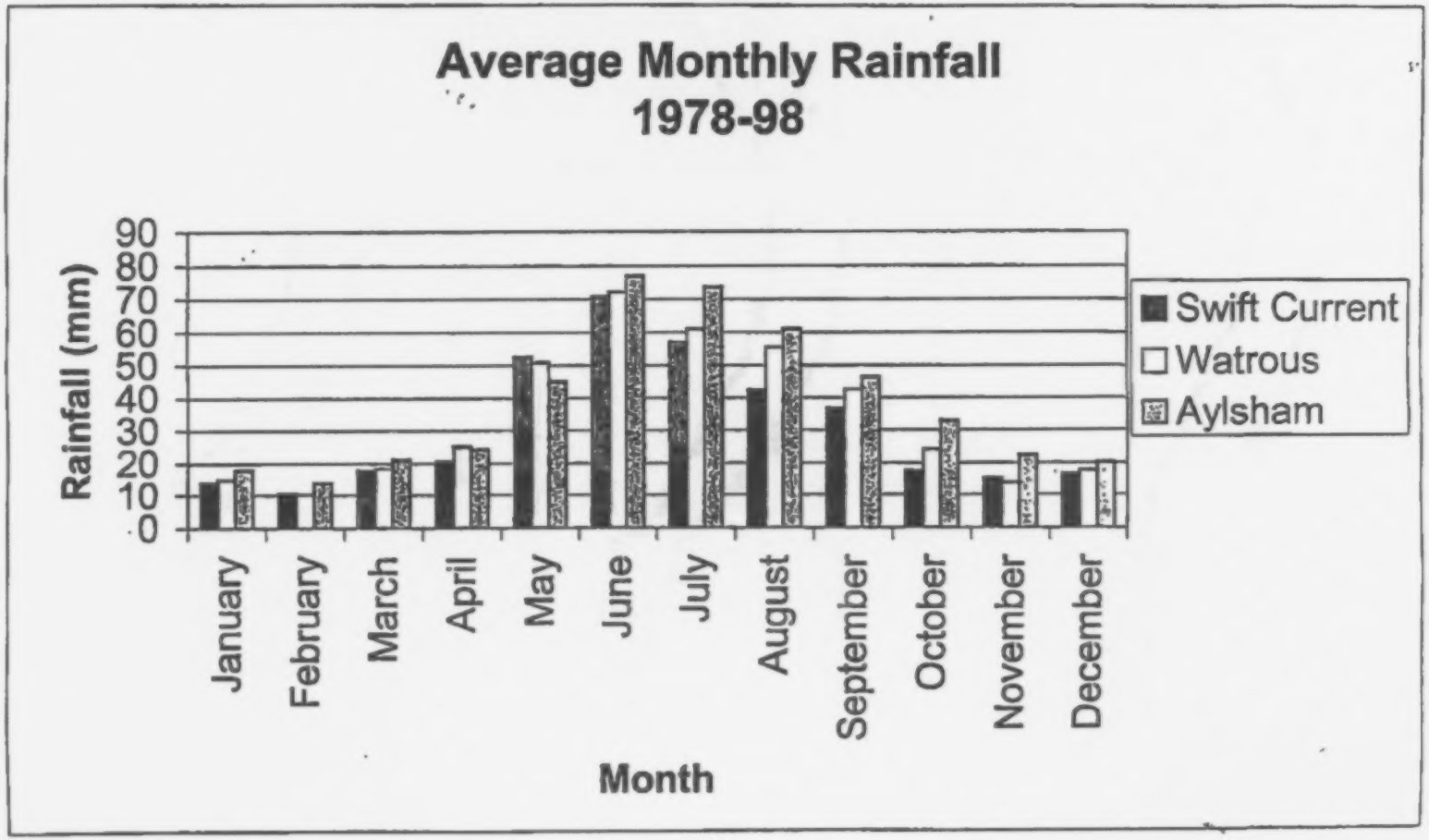
Variable Costs		Total
Feed		Cost
Barley Cost/head (summer and fall)	$ 2.44	$ 634.40
Canola meal cost/head	$ -	$ -
Feeder Cost	$ 765.00	$198,900.00
Vaccinations	$ 7.50	$ 1,950.00
Other vet Costs	$ 5.00	$ 1,300.00
Vitamin/mineral per head per year	$ 1.80	$ 458.64
Fuel	$ 2.93	$ 746.78
Utilities/office	$ 0.20	$ 52.00
Buying/Selling costs	$ 30.00	$ 7,800.00
Transportation Costs	$ 6.00	$ 1,560.00
Fence Repair	$ 1.18	$ 300.00
Fertilizer		
Amount applied (kg/ha)	50	
Cost per pound	$ 0.30	
Application cost for the section	$ 338.64	
Fert cost per head	$ 1.39	$ 353.64
Labour	$ 7.17	$ 1,827.57
Interest Rate	9%	
Interest on loan for calves/head	$ 58.51	$ 14,909.33
Drylot Costs		
Cost per day	$ 0.38	
Total Yardage Costs	$ 63.08	$ 16,400.80
Drylot Hay costs	$ 18.25	$ 4,744.15
Drylot Barley costs	$ 6.08	$ 1,581.38
Fixed Costs		
Fence and Corrals	$ 9.05	$ 2,305.78
Water System	$ 6.78	$ 1,727.07
Grass Establishment	$ 3.14	$ 800.00
Cost of Land	$ 47.10	$ 12,000.00
Grinding Feed Costs not including fuel	$ 3.51	$ 894.21
Annualized Cost of Bunk per head	$ 1.57	$ 399.81
Total Cost	$1,047.67	$271,645.55

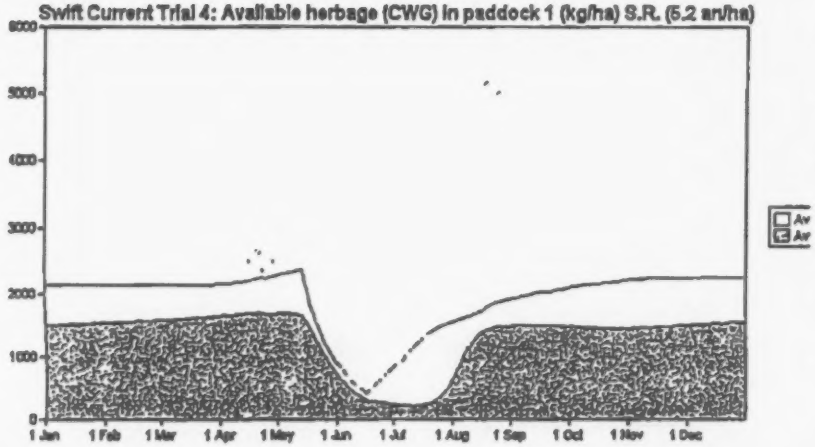
Appendix C Location Differences

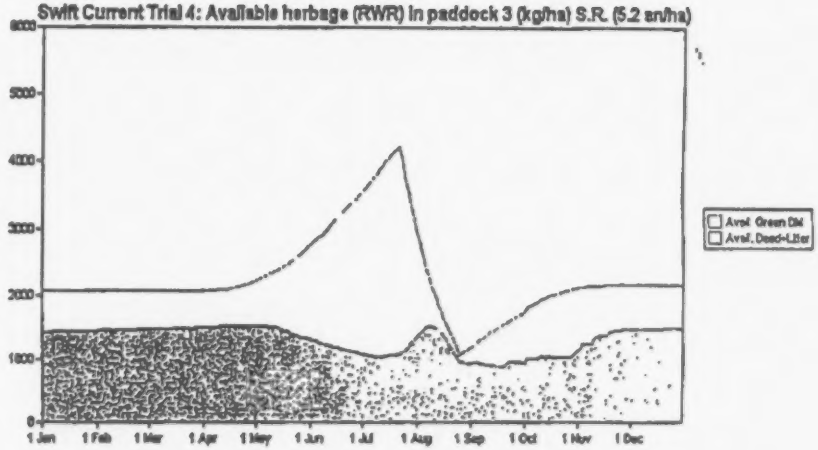

Swift Current: Average Max and Min Temperature (°C)
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec

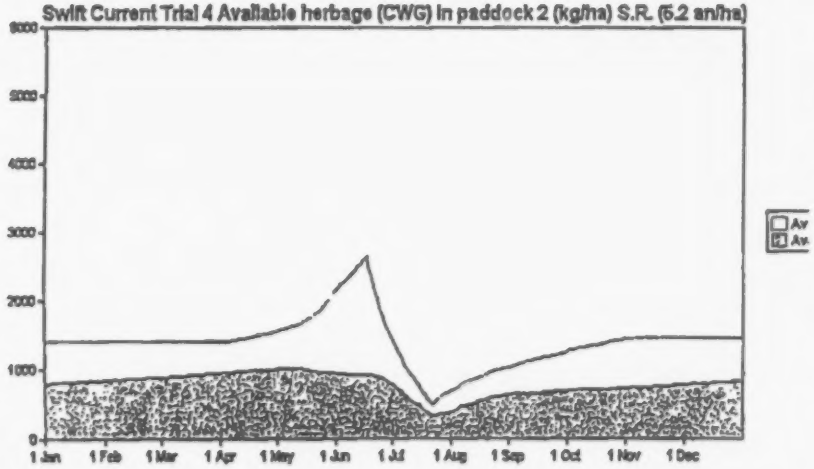

Watrous: Average Min and Max Temperature (°C)
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec

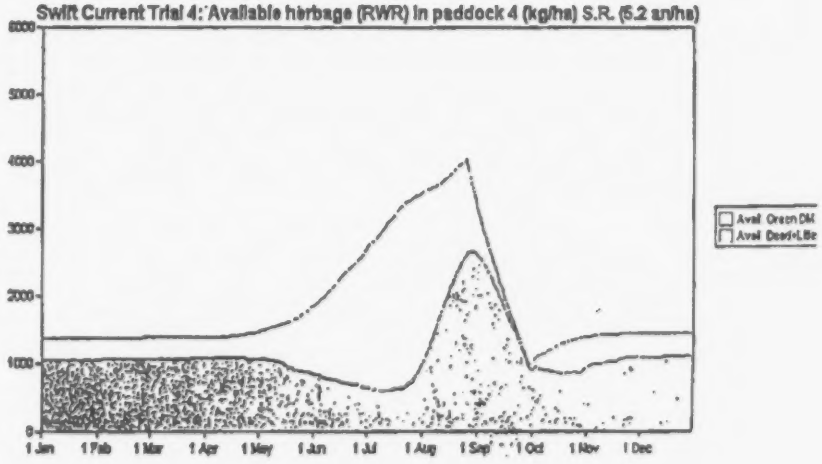

Ayisham: Average Min and Max Temperature (°C)
40.0
30.0
20.0
10.0
0.0
-10.0
-20.0
-30.0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec

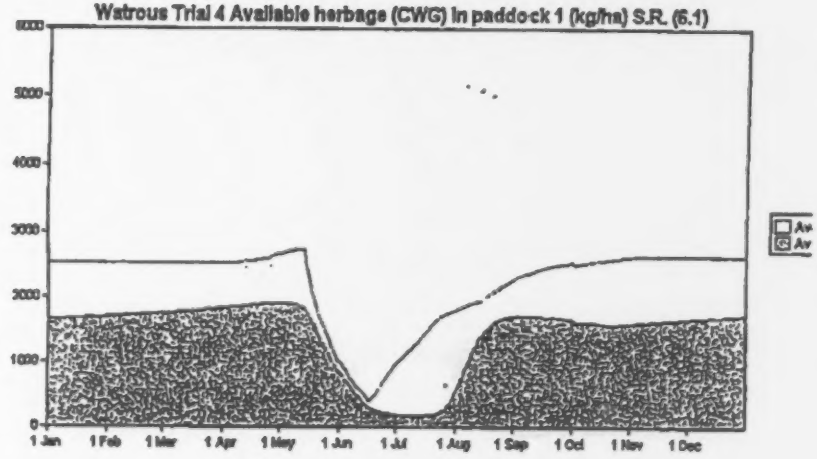

Average Monthly Rainfall
1978-98
Rainfall (mm)
90
80
70
60
50
40
30
20
10
0
January
February
March
April
May
June
July
August
September
October
November
December
Month
Swift Current
Watrous
Aylsham

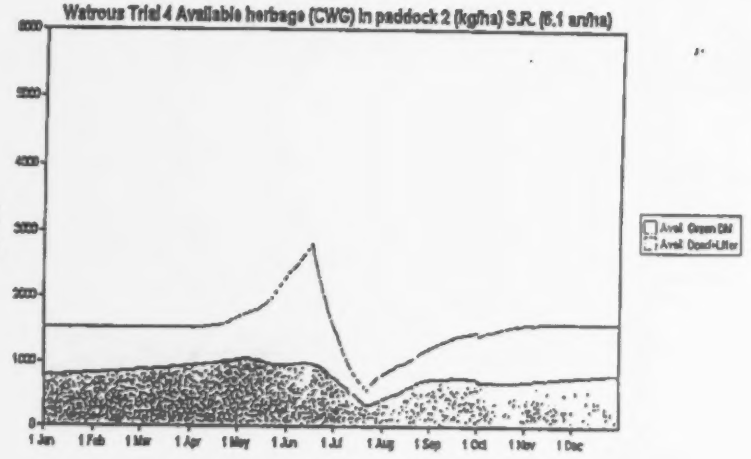

Swift Current Trial 4: Available herbage (CWG) in paddock 1 (kg/ha) S.R. (5.2 an/ha)
6000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec

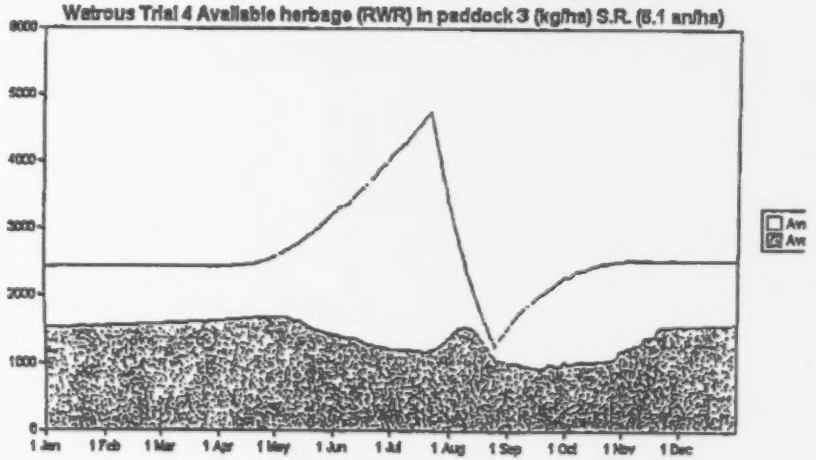

Swift Current Trial 4: Available herbage (RWR) in paddock 3 (kg/ha) S.R. (5.2 an/ha)
6000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
Avail. Green DM
Avail. Dead+Litter

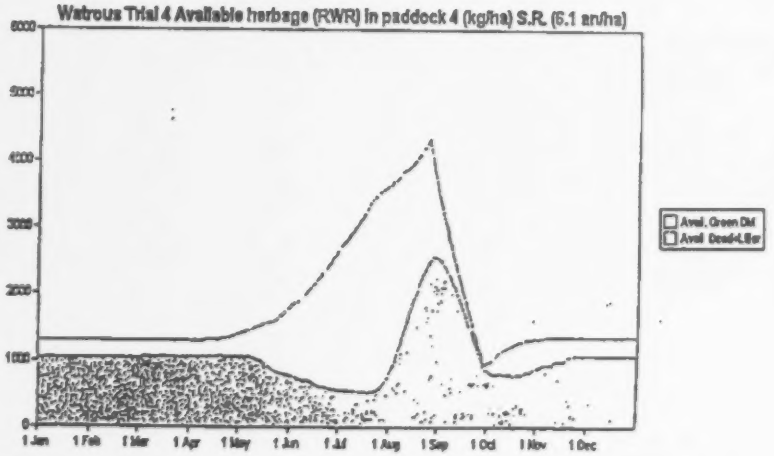

Swift Current Trial 4 Available herbage (CWG) in paddock 2 (kg/ha) S.R. (5.2 an/ha)
6000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec


Swift Current Trial 4: Available herbage (RWR) in paddock 4 (kg/ha) S.R. (5.2 an/ha)
6000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
Avail. Green DM
Avail. Dead+Litter

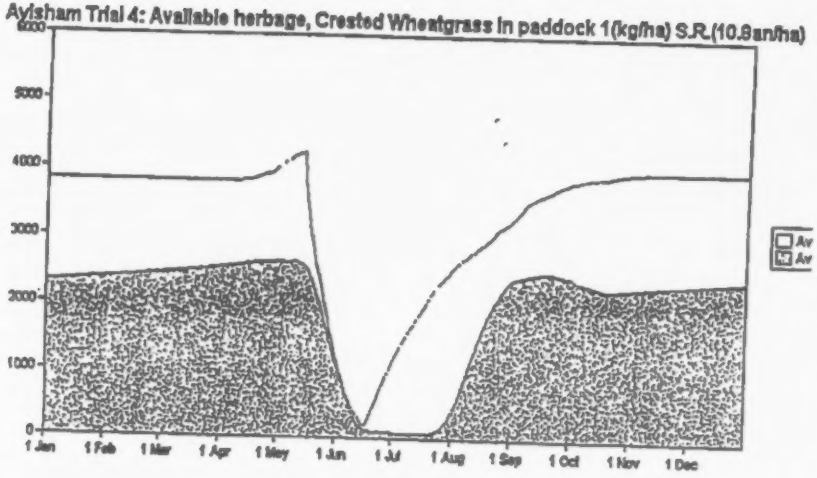

Watrous Trial 4 Available herbage (CWG) in paddock 1 (kg/ha) S.R. (6.1)
8000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec


Watrous Trial 4 Available herbage (CWG) in paddock 2 (kg/ha) S.R. (6.1 an/ha)
8000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
Aval. Green DM
Aval. Dead+Litter

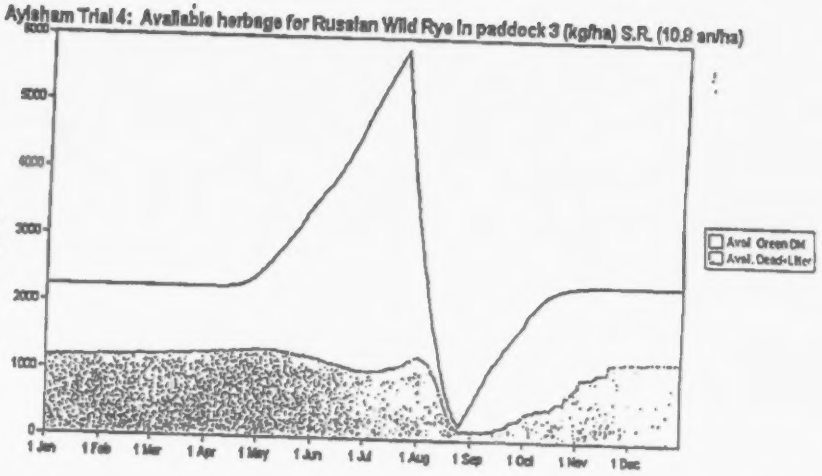

Watrous Trial 4 Available herbage (RWR) in paddock 3 (kg/ha) S.R. (6.1 an/ha)
8000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec


Watrous Trial 4 Available herbage (RWR) in paddock 4 (kg/ha) S.R. (6.1 an/ha)
8000
5000
4000
3000
2000
1000
0
1 Jan
1 Feb
1 Mar
1 Apr
1 May
1 Jun
1 Jul
1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
Aval. Green DM
Aval. Dead+Litter

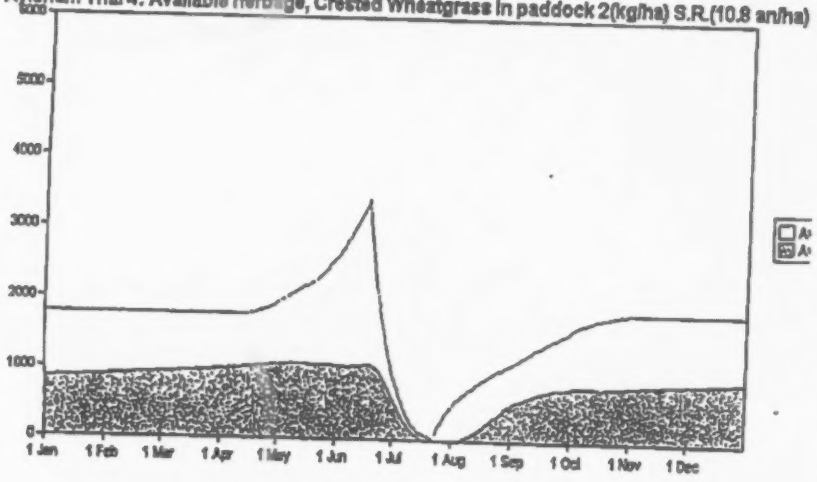
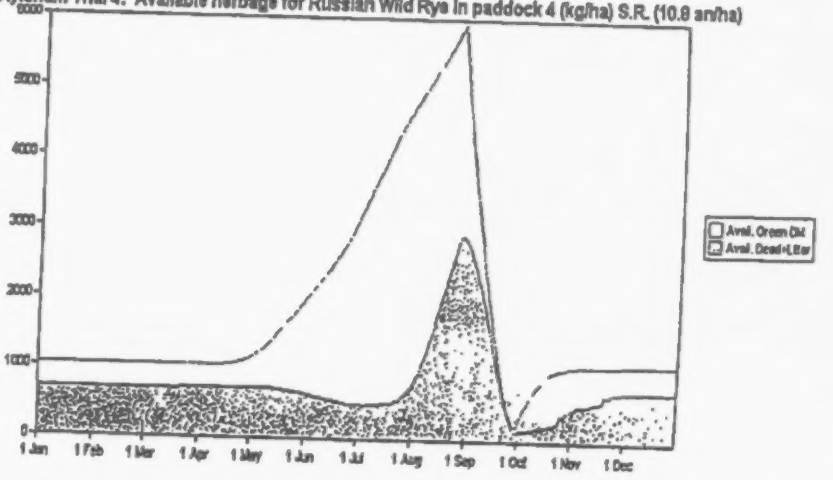
Aylsham Trial 4: Available herbage, Crested Wheatgrass in paddock 1(kg/ha) S.R.(10.8an/ha)



Aylsham Trial 4: Available herbage for Russian Wild Rye in paddock 3 (kg/ha) S.R. (10.8 an/ha)



Aylsham Trial 4: Available herbage, Crested Wheatgrass in paddock 2(kg/ha) S.R.(10.8 an/ha)



Aylsham Trial 4: Available herbage for Russian Wild Rye in paddock 4 (kg/ha) S.R. (10.8 an/ha)